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The Leaders of the Future

THE developments of the past century have been such as the most far-seeing and visionary of the thinkers of the early 1800's could not have visualized.

Instead of an aggregation of settlements, each largely sufficient unto itself, separated from each other by days of horse- or river-borne travel, receiving news from each other only by the slow-going post, and from abroad only on the arrival of a sailing packet, we have an integral nation gridironed with rails, interwoven with wires, spotted with broadcasting stations filling the air with the latest news—and other things. In the remotest and most inaccessible corner one may set up his receiver and know what is going on in the world.

And all this ease of communication and facility for transportation and exchange of products has had a prodigious effect upon the vital processes of the nation.

The simple operations of industry and exchange, controlled by local competition, have become national in scope, staggering in their magnitude and intricate in their interdependent complexity.

Great combinations of capital and enterprise and labor are struggling, each to enhance its share in the distribution of the products.

More and more each is becoming a specialist; less and less is it becoming possible for one to have a broad, inclusive, over-all comprehension of all these processes and to be competent to reconcile their conflicting interests.

As life becomes more and more complex and the problem of the development of our resources and the application of our man power along the lines of the greatest efficiency becomes more difficult and acute, where are the leaders who shall possess at once the big vision of and devotion to the general well being and a practical knowledge of processes and affairs to come from?

F. R. Low

X-Ray Tests of Welds Reveal Some Defects, but not All

THE remarkable growth of the application of fusion welding in recent years has been paralleled by the intensive scientific study of materials, apparatus and processes. There still remain, however, a few problems for which no complete solution has yet been found. In spite of the demonstrated fact that the work of well-trained and properly supervised welders (using either the oxyacetylene torch or the electric arc) is dependable, there exists a demand for some method of testing a weld without subjecting it to stress.

At present the most widely accepted test of welds as applied to pressure vessels, is the so-called "hammer test" in which the vessel is struck vigorously with a hammer in the region of the weld while subjected to a fluid pressure considerably in excess of the operating pressure. This test has proved to be of great value, as has the routine testing to destruction of occasional samples of a welder's work. The knowledge that such checks may be applied at any time without warning tends to keep all his work up to a high standard.

Valuable as are these methods of testing, there is still, as has been pointed out, a demand for some simple and reliable means of locating hidden defects in a weld without the application of force. At least two methods of accomplishing this have been suggested. One is a species of magnetic testing designed to reveal the existence of breaks in the sound metal due to internal stress, incomplete fusion, gas pockets or particles of oxide or other foreign matter. Some progress has been made with testing devices of this sort, although they have not as yet advanced beyond the laboratory stage.

The other method of testing welds without force is so obvious that it has been suggested by almost everybody from professors of physics to plumber's helpers. That is the X-ray.

For years the X-ray has been an invaluable aid in medicine and surgery. With it buried bullets are located, broken bones are inspected before and after setting, and even the heart beat is watched. The proposal that the X-ray be used to locate defects in welds is, then, a reasonable one. In fact, it has already been used in the testing of metals. An interesting recent example was the X-ray study made of the castings for the 1,200-lb.-pressure turbine built for the Edgar Station of the Boston Edison Company.[1] In this way blow holes were discovered in some of the castings before machining.

To study the possibilities and limitations of the X-ray for testing welded joints, *Power* some months ago proposed a special experimental investigation and was fortunate to secure the co-operation of the Union Carbide and Carbon Research Laboratories and the Watertown (Mass.) Arsenal. The X-ray examination was made by F. C. Langenberg, metallurgist of the Watertown Arsenal. All other experimental work was done by J. M. Keir at the Union Carbide and Carbon Research Laboratories, Long Island City, N. Y., under the supervision of S. W. Miller. The accompanying photographs, as well as the reports upon which this article is based, were supplied by these two laboratories.

AN INVESTIGATION, initiated by Power and carried out by the Watertown Arsenal and the Union Carbide and Carbon Research Laboratories, indicates that the X-ray examination of fusion welded joints is of value in revealing certain types of defects, particularly voids and oxide inclusions. The X-ray missed defects due to insufficient fusion. Improved technique may partly overcome this limitation. The results obtained by physical tests checked the judgment of the welder.

Two 12x9-in. half-inch boiler plates were scarfed at 45 deg. along one long edge of each and welded together. This type of joint is known as the single-V 90-deg. bevel. The 12-in. weld was divided into four zones of about 3-in. each. These zones are indicated on the left of Fig. 1, which shows the welded plate after completion of the X-ray tests and laying out for cutting the physical test specimens. According to the original notes of the welder the jobs done in the four zones were as follows:

Zone 1 — Bad weld. Welded at bottom with small tip, then melted in rod and made good job at top.

Zone 2—Good weld.

Zone 3—Poor weld. Some laps. Covered up slag and fused to V, but bad in center.

Zone 4—Fair weld. Rubbed metal along side with rod and got to stick in spots.

It should be particularly noted that these comments were made at the time of welding and were therefore not influenced by any knowledge of the results of the tests. The fact that the general conclusions from the tests agreed with the welder's preliminary judgment reinforces the claim of welding experts that a skilled welder can always tell when he is doing a good job.

After welding, the specimen was sent to the Watertown Arsenal, where the six X-ray photographs reproduced herewith (Figs. 3-8) were made. To understand these photographs it is first necessary to have a general idea of how they were made.

In taking X-ray pictures no lens is used. The X-ray tube is placed above the object to be studied and a photographic film below. The rays move out in straight lines from the bulb, penetrating the object in inverse proportion to the resistance encountered. What strikes the film is nothing but a "shadow" of variable darkness —such a shadow as might be cast on a piece of white paper by a candle light passing through a piece of mottled glass. X-rays do not pass through iron as

[1] See *Power* June 30, 1925.

easily as through flesh, but with a sufficiently long exposure they will register.

Where the rays traverse a cavity in the metal, the resistance is thereby reduced and the shadow lightened. Conversely, extra-dense metal (or greater thickness) makes the shadow deeper. X-rays, like ordinary light, turn the photographic film dark (after development); the developed film is in effect a reversed shadow. The deeper parts of the shadow show light and the light parts show dark.

If a print is made from the film, the shadow is again reversed back to its original condition.

All the accompanying photographs correspond in appearance to the prints rather than the films; that is, they are light where the X-rays got through easily and dark where the resistance was greater. Thus light streaks or spots indicate cavities or cracks or at least

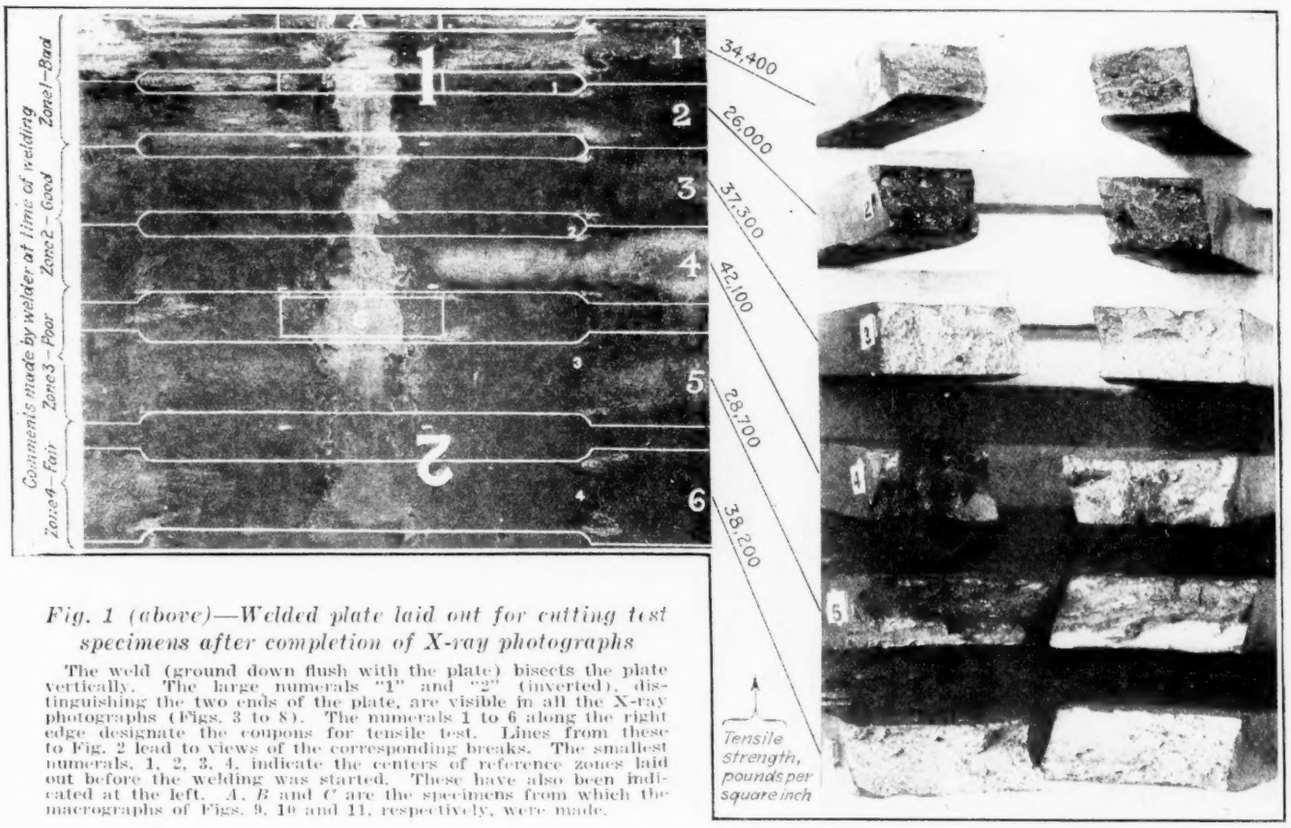


Fig. 1 (above)—Welded plate laid out for cutting test specimens after completion of X-ray photographs

The weld (ground down flush with the plate) bisects the plate vertically. The large numerals "1" and "2" (inverted), distinguishing the two ends of the plate, are visible in all the X-ray photographs (Figs. 3 to 8). The numerals 1 to 6 along the right edge designate the coupons for tensile test. Lines from these to Fig. 2 lead to views of the corresponding breaks. The smallest numerals, 1, 2, 3, 4, indicate the centers of reference zones laid out before the welding was started. These have also been indicated at the left. *A*, *B* and *C* are the specimens from which the macrographs of Figs. 9, 10 and 11, respectively, were made.

the presence of some substance with less resistance to the rays than pure sound metal.

Dark patches indicate greater resistance. This is not necessarily due to greater density of the metal. The welds show darker than the adjacent metal because they were slightly thicker in spite of the fact that the weld was ground down close to the plate.

Being nothing but a shadow picture, an X-ray photograph is affected greatly by the direction of the rays in respect to the object. For instance, if a crack exists it should show more plainly when turned "edge-on" to the rays. A thin crack whose plane was at right angles to the rays would not be expected to have much effect on the rays.

The two sides of the V, as already noted, make an angle of 45 deg. with the plane of the plate. To reveal any flaws accumulating along these surfaces, X-ray photographs were taken with the rays approaching the weld first from the left and then from the right, and in both cases at an angle of 45 deg. with the surface of the plate. In addition, an ordinary X-ray photograph was taken with the rays striking the weld at right angles to the surface.

Because of the size of the specimen it was necessary to take two such sets of three photographs each. The two sets cover the full 12 in. length of the weld and overlap considerably at the center.

Before making the photographs, the extra metal on the weld was ground down as close to the surface of the plate as possible, as already pointed out. This was necessary to avoid the shadow effect of variable thickness.

After the X-ray work had been completed, the plate was returned to the Union Carbide and Carbon Research

Fig. 2—Breaks obtained with tensile test coupons shown in Fig. 1

Tensile strengths in pounds per square inch are shown on connecting lines. Note that they check roughly with the welder's original judgment. Some of the breaks show poor fusion along the scarf and lack of penetration to the bottom of the V. A side view of the break of Coupon 4 is shown in Fig. 12. There is evidently serious lack of fusion along the scarf, but this is not shown in the X-ray photographs. The X-ray also failed to indicate the small fissures running nearly parallel with the length of the coupon.

Laboratories to be cut up for physical tests. Fig. 1 shows the plate marked up for cutting out the test specimens. The five tensile coupons are identified by the numbers on the right of the photograph. These were cut out and tested for ultimate strength. Additional information was gained by a study of the appearance of the corresponding breaks, as shown in Fig. 2. The ultimate strengths of the various coupons

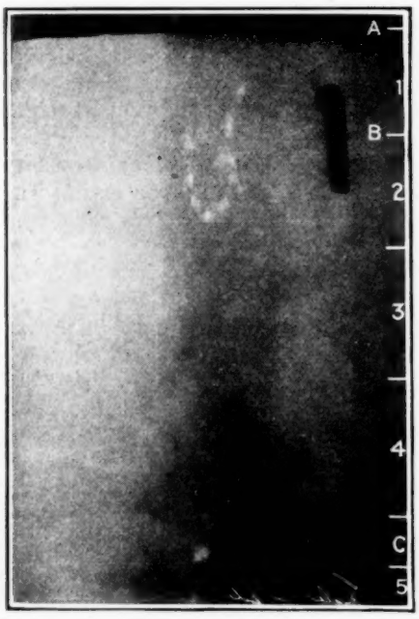


Fig. 3—Tube at left and rays parallel to left scarf

Defects are visible in region of Coupons 1 and 2. These defects roughly follow two vertical lines, joined by a loop at the bottom, suggesting that they lie along the scarfs. Middle welding (Coupons 3 and 4) looks good. Large void is visible in *C*.

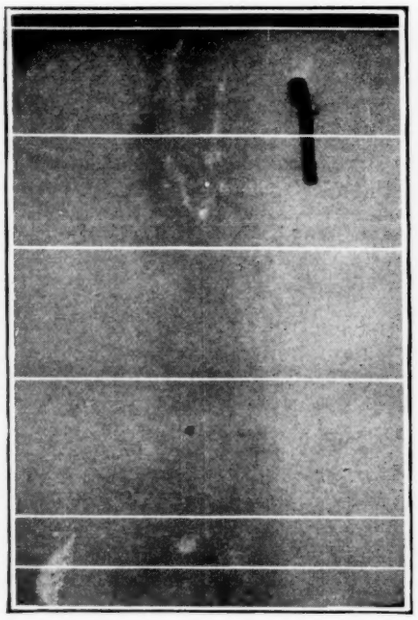


Fig. 4—Tube directly over weld with rays perpendicular to plate

Small voids and oxide inclusions seem to be indicated by the light spots in Coupons 1 and 2. Figs. 3 and 5 indicate that these defects are mostly along the scarfs. The welding metal appears denser than metal of the plate because of its greater thickness.

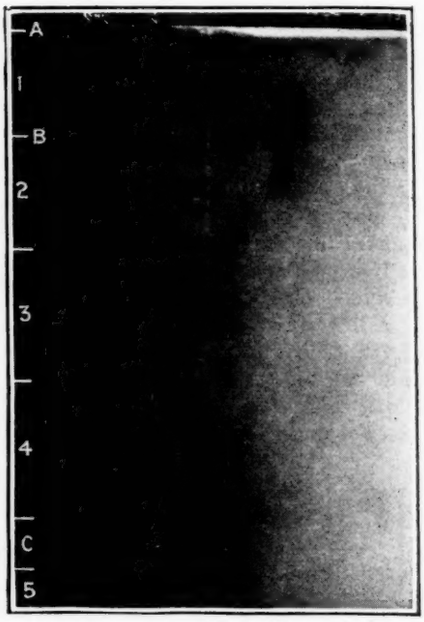


Fig. 5—Tube at right and rays parallel to right scarf

The light vertical line in Coupons 1 and 2 seems to indicate a series of voids along right side of scarf. Study of the sideways shifting of the void in *C* in Figs. 3, 4 and 5 indicates that it and the smaller nearby defects are in the body of the weld.

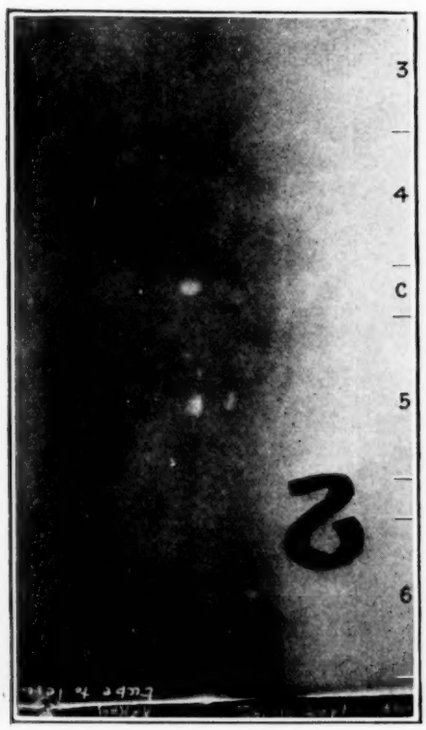


Fig. 6—Tube at left and rays parallel to left scarf

Each picture in the lower row corresponds to that above it except that it is centered on the lower part of the plate. In this photograph there is no clear indication of a defect along the scarf in Coupon 6 as was expected to be shown by the tilting of the plate. Note voids in *C* and in Coupon 5.

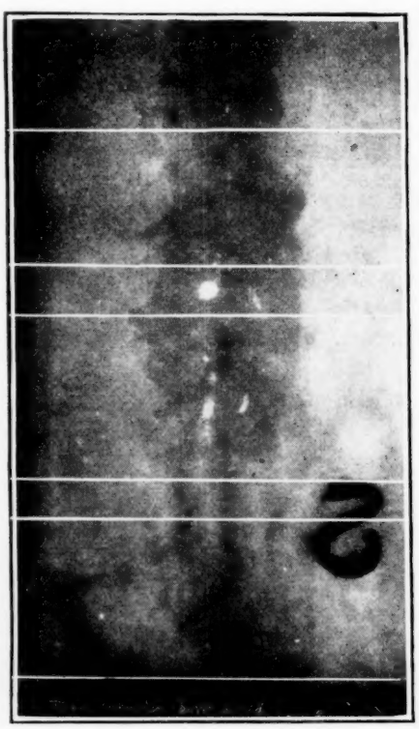


Fig. 7—Tube directly over weld with rays perpendicular to plate

With the tube in this position the line of junction at the bottom of the V in Coupons 3 and 4 may be seen, indicating lack of penetration. In other respects the welding in this section seems to be good. The previously noted voids and inclusions in *C* and Coupon 5 show up more clearly.

Fig. 8—Tube at right and rays parallel to right scarf

The weld in Coupons 3 and 4 seems to be fairly homogeneous, free from voids, and generally a fine piece of work. This checks with the other photographs. The defects in *C* and Coupon 5 show up again. The weld in the lower end of the plate appears to be sound as in Figs. 6 and 7.

are given on the cut. Macroscopic[2] photographs were made of sections taken from *A*, *B* and *C*. These are shown in Figs. 9, 10 and 11.

To avoid annoying the reader by requiring him to refer constantly from text to photograph, most of the detailed observations have been incorporated in long

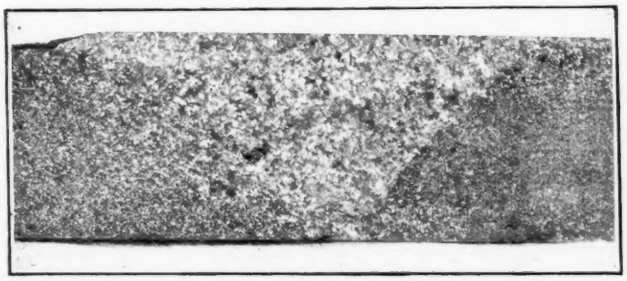


Fig. 9—A macroscopic view of the weld at specimen A (see Fig. 1)

A few small voids may be noted on the surfaces of the scarf and in the body of the weld. Similar defects are indicated by the X-ray in Figs. 3, 4 and 5.

captions. The following comments are in the nature of a summing up of these observations.

In Zone 1, the welder deliberately did a bad job. His comments were "Bad weld. Welded at bottom with small tip, then melted in rod and made good job at top." This is the region covered by the test coupons 1 and 2 and macroscopic specimens *A* and *B* as indicated in Figs. 1, 2, 3, 4, 5, 9 and 10. The X-ray photos

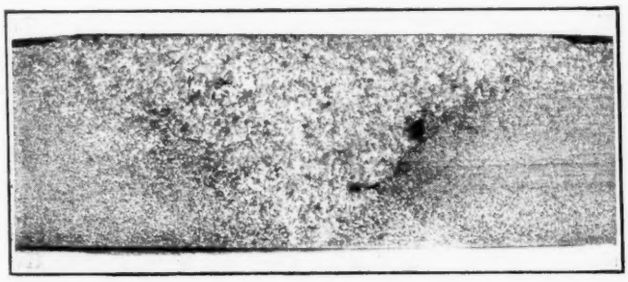


Fig. 10—A macroscopic view of the weld in specimen B (Fig. 1)

Small voids are here visible along the scarf and in the body of the weld. These seems to be satisfactorily shown in Figs. 3, 4 and 5.

(Figs. 3, 4 and 5) showed what seem to be poor penetration and also other defects along the two scarfs in this region. Some defects—porous metal and oxide inclusions—also seemed to be present in the body of the weld. Tensile Coupon 1 showed the ultimate strength of 34,400 lb. per sq.in., while Coupon 2 dropped off to 26,000, giving an average for Zone 1 of only 30,200 lb. The poor fusion may be seen by studying the breaks in Fig. 2. These followed one surface of the V. Some small voids along the faces of the V and in the body of the weld may be noted in Figs. 9 and 10.

Zone 2 was labeled "good weld" by the welder. The tensile tests of Coupons 3 and 4 (37,300 lb. and 42,100 lb. respectively, with an average of 39,700 lb.) bear out his judgment. The X-ray failed, however, to show the lack of fusion at the bottom of the V which may be seen on the break of Coupon 4 in Fig. 2.

[2]A macroscopic photograph is one made with a small magnification.

The welder referred to Zone 3 as "Poor weld. Some laps. Covered up slag and fused to V, but bad in center." The corresponding test specimens are *C* and Coupon 5. All six X-ray photographs showed a large void and some small ones in *C*. These are clearly shown in Fig. 11. The existence of many voids and inclusions in Coupon 5 as shown in the X-ray photographs is borne out by the low tensile test of 28,700 lb. obtained with this specimen. The X-ray did not, however, reveal the lack of fusion along the faces of the scarf which is evident in the break of Coupon 5 (Fig. 2).

Zone 4, which the welder describes as "Fair weld. Rubbed metal along side with rod and got to stick in spots," showed no material defects in the X-ray photographs. Yet the break in Coupon 6 (Fig. 2) indicates very poor fusion along the face of the V.[3]

To sum up, the tests made show definitely that the X-ray is capable of revealing such defects as gas pockets, oxide inclusions and cracks nearly parallel with the

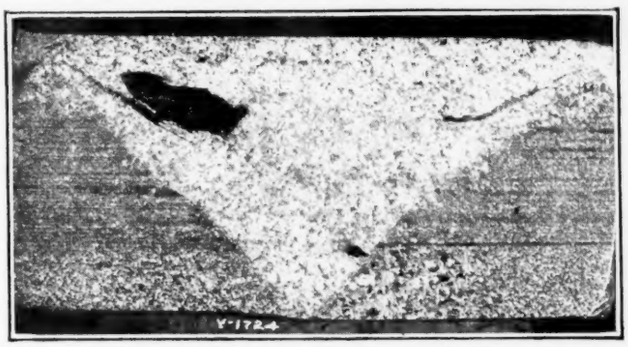


Fig. 11—Macroscopic view of the weld in specimen C (Fig. 1)

The large void shown is clearly visible in all the X-ray pictures. It is evident that a considerable portion of the scarf has been poorly fused, as shown by the sharp line of demarcation. This is most prominent on the lower half of the left-hand scarf. The X-ray failed to reveal this defect.

rays, but that with the methods employed there will be little if any indication of poor fusion. The apparent shortcomings of the X-ray may possibly be overcome

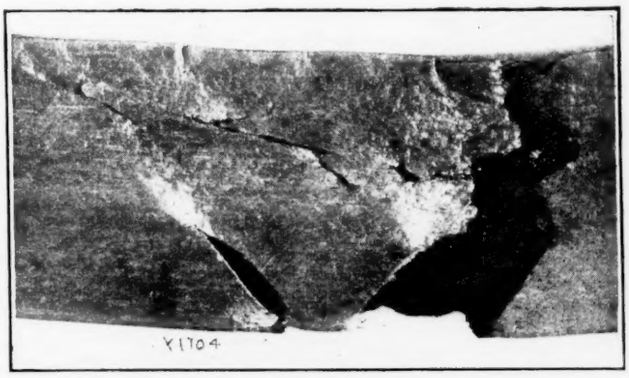


Fig. 12—Side view of break in coupon 4 (Figs. 1 and 2)

Insufficient fusion along the bottom of the V is clearly shown, as is a fissure stretching across the weld. This has probably been caused by a "lap," that is, by the welder permitting fused metal to flow over a unfused surface. The X-ray did not reveal this serious defect.

by future advances in X-ray technique. For general application of the X-ray to the testing of welds, the apparatus should also be made much less cumbersome.

[3]The high tensile test of 38,200 lb. obtained with coupon 6 seems to be one of those occasional freaks difficult to explain.

Auxiliary Supercooling in Surface Condensers

By A. J. NICHOLAS

THE FUNCTION of a condenser is to condense the exhaust steam from a prime mover, and thus to maintain a low exhaust pressure. To do this efficiently it should (1) utilize the minimum cooling surface with minimum cooling water and maximum heat interchange between steam and cooling water, (2) discharge the condensate at as high temperature as possible, as determined by the vacuum maintained and

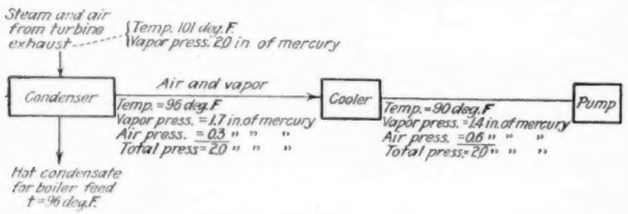

Steam and air from turbine exhaust
Temp. 101 deg. F.
Vapor press. 2.0 in. of mercury
Condenser
Air and vapor
Temp. = 96 deg. F
Vapor press. = 1.7 in. of mercury
Air press. = 0.3 " " "
Total press = 2.0 " " "
Cooler
Temp. = 90 deg. F
Vapor press. = 1.4 in. of mercury
Air press. = 0.6 " " "
Total press = 2.0 " " "
Pump
Hot condensate for boiler feed
t = 96 deg. F

Fig. 1—Diagram of condenser and air cooler layout

(3) cool the residual steam-air mixture to a low temperature before its removal by the vacuum pump.

Item 1 is the most important in condenser design and is governed by choosing the proper size, number and spacing of tubes and shape of chamber. The number and size of tubes give the rate of flow of the cooling water. The spacing of tubes and chamber shapes determine the rate of flow of the exhaust steam and air in their downward course through the condenser. The relation of these two determines the conditions existing in the exhaust chamber. The velocity of the steam and air should be kept uniform and constant in their travel from the top to the bottom of the condenser. This makes each tube effective in the removal of heat from the steam and prevents stratification of the steam-air mixture, which is the cause of hot spots and non-uniform temperature in the condenser and thus makes some tubes less effective than others.

Item 2 is desirable in that it reduces the heating of the condensate when it is used as boiler feed. Item 3 is desirable, because the capacity of the air removal pump required to serve the condenser is considerably reduced by cooling the steam-air mixture entering the pump suction.

Condensate vs. Steam-Air Temperatures

Unfortunately, it is impossible to realize a high condensate temperature and a cool residual steam-air mixture in the same shell. If, in a single shell without baffling or other separation of parts, the cooling is carried to a low temperature so as to realize item 3, then the condensate temperature will be low and item 2 is sacrificed. If, on the other hand, hot condensate is obtained, the steam-air mixture will be at the same high temperature and a larger vacuum pump will be necessary.

The tubes in the main body of the condenser should extract the major portion of heat from the steam, leaving hot condensate at the bottom for use in the boilers. The minor portion of heat should be handled by an auxiliary cooler specially built to handle the residual steam-air mixture rich in air. Such a condenser plant is shown in the diagram of Fig. 1. With a separate cooler it is possible to have hot condensate and a cool steam-air mixture before it is withdrawn by the vacuum pump, and so to use a vacuum pump of small dimensions and still maintain a high vacuum in the condenser.

To show this concretely, suppose that the condenser plant of Fig. 1 is maintaining at the steam inlet an absolute pressure of 2 in. of mercury. Thermocouples at various points in the condenser shell will show no appreciable drop in temperature until more than 99 per cent of the steam has been condensed. Throughout the main condenser shell the temperature will be substantially 101 deg. F., but at the point of departure of the residual steam-air mixture, where there remains only a trace of steam, the temperature drops rapidly as condensation proceeds. Suppose that at this point the temperature has fallen to 96 deg. F. In a simple open condenser shell, the condensate temperature will also be about 96 deg. F.

While passing through the external cooler shown in the diagram of Fig. 1 the steam-air mixture is cooled and devaporized. The typical curve of Fig. 2 shows what takes place. The portion *AB* of the steam is

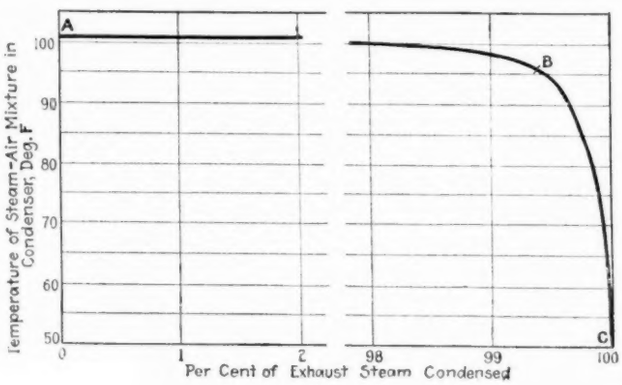


Fig. 2—The bulk of the steam is condensed at substantially constant temperature

condensed by the main condenser tubes, and the portion *BC* by the auxiliary supercooler. Thermocouples located in the cooler will show a drop in temperature as the steam-air mixture approaches the vacuum pump suction connection.

If no cooler were present, the residual steam-air mixture would be drawn off at the same temperature as the condensate. The partial pressure of the steam in this mixture, as found in the steam table, would be 1.7 in. of mercury and that of the air would be 0.3 in. of

mercury, the sum being equal to 2 in., the absolute total pressure assumed. The volume of this air at the condition of withdrawal from the condenser would be approximately 30 ÷ 0.3 = 100 times the volume of free air at atmospheric pressure.

Suppose, on the other hand, that the mixture is passed through a cooler and is cooled to 90 deg. F. before withdrawal by the vacuum pump. The partial pressure of the steam at this temperature would be 1.4 in. of mercury and that due to the air would necessarily be 0.6 in. of mercury, since the sum must equal the absolute pressure of 2 in. (friction having only a small effect on pressure). The volume of this air at the condition of withdrawal from the cooler would be 30 ÷ 0.6 = 50 times the volume of free air at atmospheric pressure. It is evident, then, that by reducing the temperature of the steam-air mixture 6 deg. before withdrawal by the vacuum pump, the volume of air that the pump must handle may be reduced to half. This means that a given pump would handle twice the weight of air for the same effective displacement.

Effect of Supercooling on the Volumetric Efficiency of the Vacuum Pump

Fig. 3 shows how supercooling affects the volumes of air which the pump would handle for various degrees of cooling. In addition to this, the volumetric efficiency of the pump changes with temperature, but not in direct proportion to the volume changes. The vacuum, stroke, valve design, clearance and leakage also influence the volumetric efficiency of a vacuum pump. Fig. 4 shows the comparative volumetric efficiencies of a vacuum pump at various steam-air mixture temperatures, as found by actual tests. This curve is drawn up with air as a standard—that is, the volumetric efficiency is

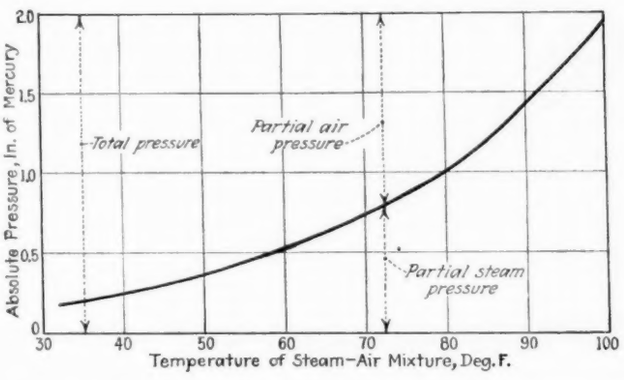


Fig. 3—The partial pressure of air rises rapidly as the temperature falls, and the volume of air is inversely proportional to its partial pressure

indicated in Fig. 4 as a percentage of the volumetric efficiency of the same pump when handling dry air alone. It is evident from Fig. 4 that up to about 68 deg. F. the volumetric efficiency of a pump handling steam-air mixture is the same as if the pump handled dry air alone. The volumetric efficiency of a certain vacuum pump handling air alone at 2 in. of mercury absolute pressure is about 56 per cent. This is the 100 per cent figure indicated in Fig. 4. It is evident that for a cooling of 6 deg. (from 96 to 90, as assumed) the comparative efficiency would be raised from 51 to 77 per cent of the dry air value. The actual volumetric efficiency of the given pump under these conditions would be 0.51 × 0.56 and 0.77 × 0.56, or 28.5 and 43 per cent respectively, a net gain of 14.5 points. In actual practice the yearly average of the cooling water temperature is around 70 deg. F., giving mixture temperatures between 80 and 85 deg. F. Under these conditions the average comparative volumetric efficiency of the vacuum pump, taken from Fig. 4, would be between 94.5 and 88.5 per cent of the dry air value, so that

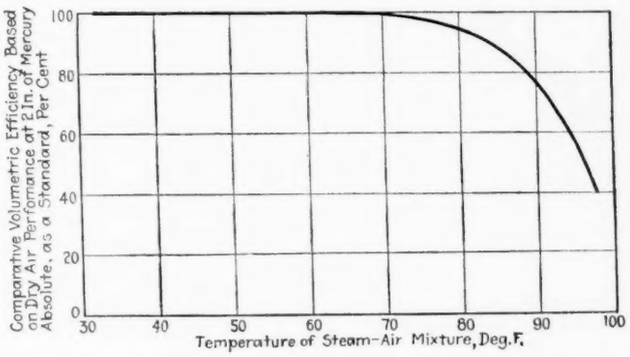


Fig. 4—The volumetric efficiency of a vacuum pump falls off with rising temperature

the actual volumetric efficiency of the given pump under these conditions would be 0.945 × 0.56 and 0.885 × 0.56, or 52.8 and 49.5 per cent respectively.

It is therefore clear that the cooling of the residual steam-air mixture leaving a condenser, before it reaches the vacuum pump, is a powerful means of either increasing the capacity of the pump of an existing installation or reducing the size of pump required for a new job.

Two months ago the Bureau of Mines distributed a questionnaire in which opinions were sought regarding the proposed change from the "gallon" to the "barrel" (42 U. S. gallons) as the unit for liquid refined products. The results of this canvass to date are as follows: For, 700; against, 175. This shows a majority of four to one in favor of the change, hence the Bureau of Mines feels justified in changing from the gallon to the barrel as the unit of measurement of liquid refined products. The main argument of those opposed to the change was that the value of past figures and graphs would be seriously impaired. The Bureau of Mines is prepared to meet this objection by changing all its back figures to the new basis. This is a considerable job and it will be some time before the change will be completely inaugurated.—*G. R. Hopkins, Bureau of Mines.*

The paint manufacturers' slogan, "Save the surface and you save all," has some application to pipe covering. Many a job of pipe covering depreciates more rapidly than it should because of faulty protection on the outside. The best jobs are finished off either with hard-finish cement or with heavy duck sewed with linen twine and then coated with waterproof paint. Where high steam temperatures exist, the life of the inner surface may be prolonged by the use of insulation in two layers, the inner layer being of a temperature-resisting insulating material.

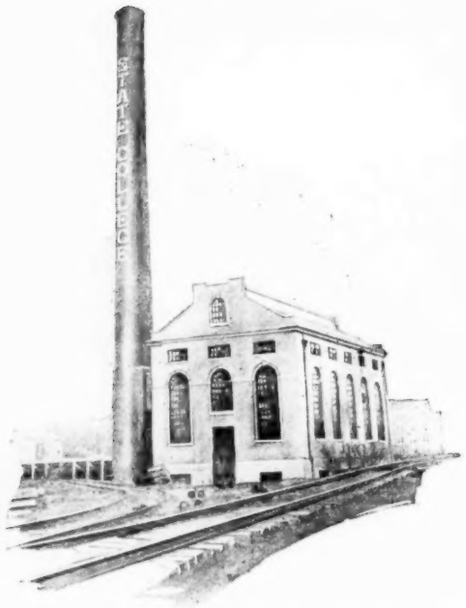


Fig. 1—New power house

Power Plant Used for a Laboratory at the North Carolina State College

THE new power plant of the North Carolina State College of Agriculture and Engineering, Raleigh, N. C., was designed to supply light, heat and power to the college buildings and to be used as a part of the laboratory equipment of the mechanical engineering department. Both a turbine and a reciprocating engine are installed. The boiler room is completely equipped.

IN MANY schools the power plant is as forbidden a territory to the engineering students as that of some outside factory. When it was decided to construct a new power plant at the state agricultural and engineering college at Raleigh, N. C., the idea that the plant should be, in effect, a part of the mechanical engineering laboratory was advanced and accepted. Consequently, the choice of machinery was made with the view not only of providing economical power, but also with that of permitting the students to work with and become acquainted with modern power-plant equipment.

While a connection was and is still had with the local lighting system, it was felt that the college should generate its own power as well as provide heating service. This was for the reason that although the lack of cooling water necessitated non-condensing operation, the electrical generating portion of the plant would be chargeable with but a small overhead. The greater portion of the boiler load would be the steam supplied to the buildings, and this requirement practically dictated the boiler capacity to be installed. Likewise, all the other plant equipment save the generating units and the generator panels of the switchboard would be needed even with the electrical supply obtained outside. The plant force would be the same in either case, with the exception of the day oiler. The cost of generating electrical energy would be the cost of the coal plus the overhead charges on the generating units plus the wages of one oiler. Even if the cost were higher, the educational advantages justified the action.

In the old plant a 13x12-in. single-valve automatic high-speed engine was direct connected to a 75-kw. alternator, and this unit was to be installed in the new plant as a breakdown set. In deciding upon the type of new generating unit to carry the load, it was realized that the students should become acquainted with turbines as well as reciprocating engines. Even though a small non-condensing turbine has a high water rate compared to some reciprocating engines, it was determined to install a 200-kw. turbo-generator. The increase in steam consumption could quite properly be charged to the cost of operating the mechanical laboratory, although this charge has not been made.

In deciding upon the boilers and upon the pressure to be carried, it was felt that even in a plant where the steam output would seldom exceed 15,000 lb. per hour, modern tendencies should be observed. Consequently, two 3,945 sq.ft. and one 2,340 sq.ft. vertical inclined-tube water-tube boilers of the three-drum type were specified, with steam at 175 lb. pressure and 50 deg. superheat. Under each of these boilers was placed an underfeed stoker driven by an electric motor.

Steam is taken from the boiler at about 155 lb. and

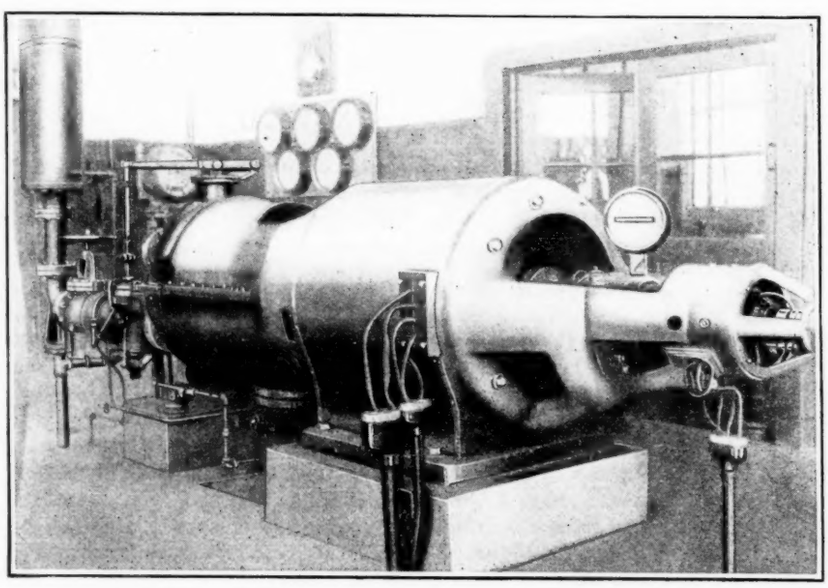
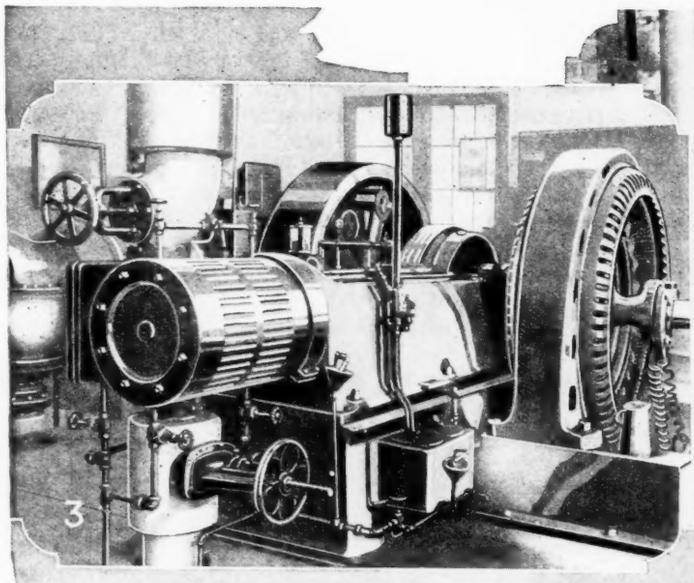
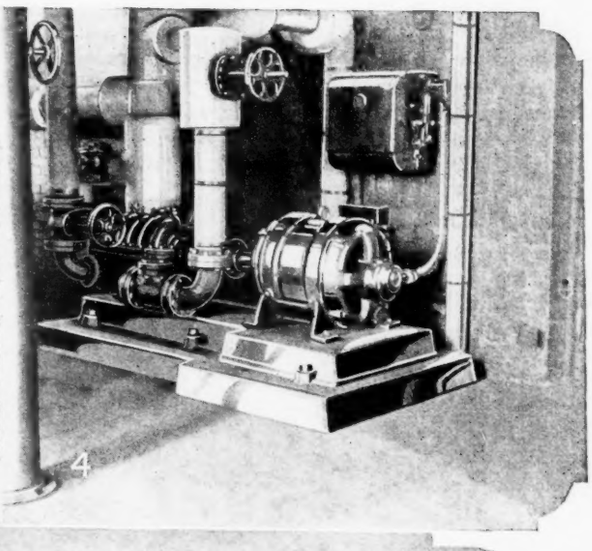


Fig. 2—200-kw. turbo-generator carrying college load





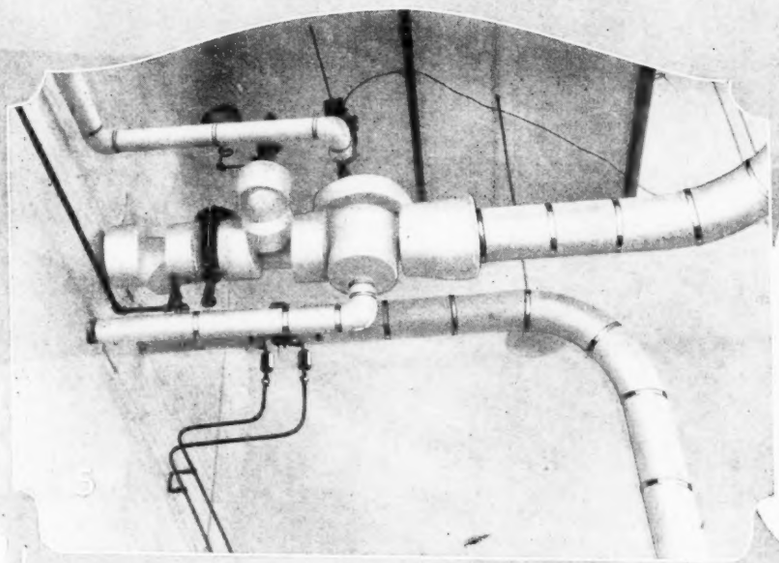


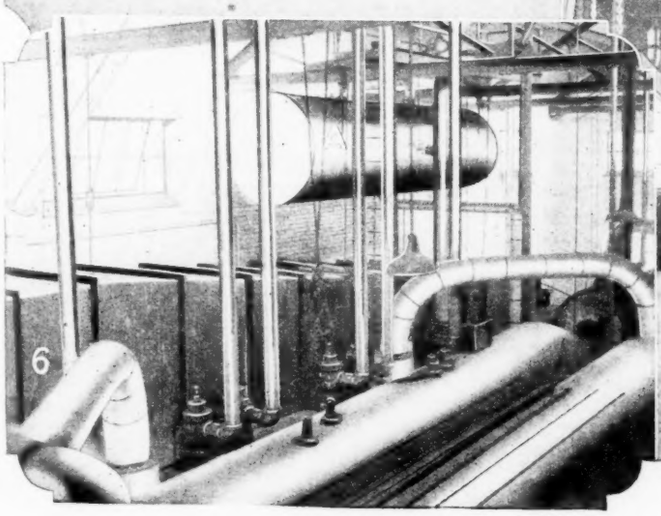
Fig. 3 — High-speed engine for breakdown service

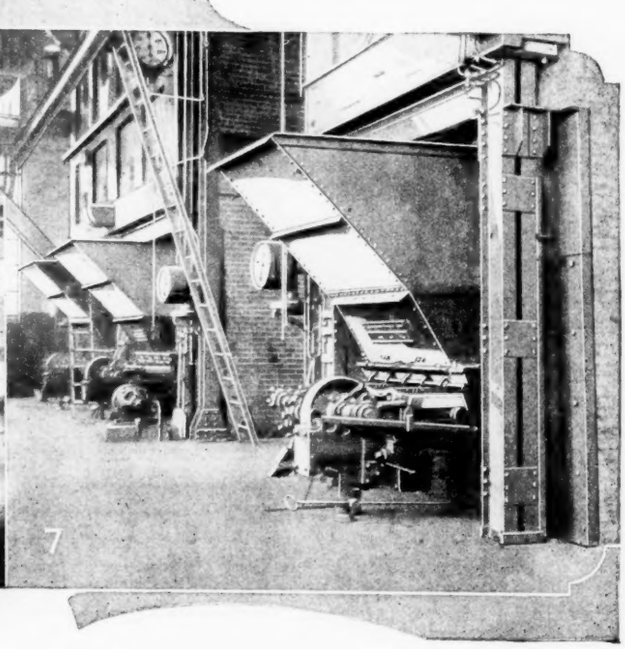
Fig. 4—5-stage motor-driven centrifugal feed pump

Fig. 5—Apparatus to lower pressure and temperature of steam to engine

Fig. 6 — View of top of boiler showing breeching and feed tank

Fig. 7—The three boilers equipped with stokers





enters the heating system at this pressure or is first passed through a reducing valve in the boiler room and enters the mains at 85 lb. At the buildings this is lowered by reducing valves to approximately 2 lb. The returns are handled by one of two motor-driven centrifugal vacuum pumps installed in a pit below the basement floor.

Feed water consists of the condensate from the heating system and makeup from the city mains. This makeup covers not only the ordinary wastage, but in addition, the amount of exhaust steam from the turbine that escapes from the atmospheric line. From the centrifugal vacuum pumps the hot-water returns are pumped into a large cylindrical tank located above the boilers, shown at *A* in Fig. 6. This contains a float that actuates a balanced valve on the makeup line. If the water level in the tank drops below a predetermined point, the float admits city water into the line leading to the open heater. The advantage of the tank is that when a large amount of condensate is pumped out of the heating system at a time when the boilers are operating light, no wastage through the heater overflow occurs. The open heater is placed on a steel structure above the boiler-room floor and between boilers Nos. 2 and 3; being equipped with a weir meter, the water supply to the boiler is noted on the daily log sheet.

The exhaust lines from the turbine and engine drop below the engine-room floor, which is on the same level as the boiler room, and after making a connection with the hot-water service tanks pass into the boiler-room basement, upward into the heater, and out through the atmospheric line.

From the heater the feed water is forced into the boiler by a 10x7x10-in. outside-packed, steam-driven duplex pump. Although a 5-stage centrifugal pump is provided, it is not deemed advisable to operate it since students handling the plant after 10:30 p.m. are not as attentive as regular firemen. It was found that they often allowed the motor-driven pump to run after the generating units had been shut down at 10:30 p.m. and connection had been made with the public service line. In connection with the feed lines an interesting change from standard practice was made. A line was run from the discharge of the pump to the blowoff line. If a gasket leaks or a fitting breaks on the regular feed-water line, feed to the boiler may be at once established through the blowoff. During the preliminary operation of the plant such troubles occurred three times and the blowoff connection probably saved damage to some of the tubes.

The hot-water service for the several buildings is

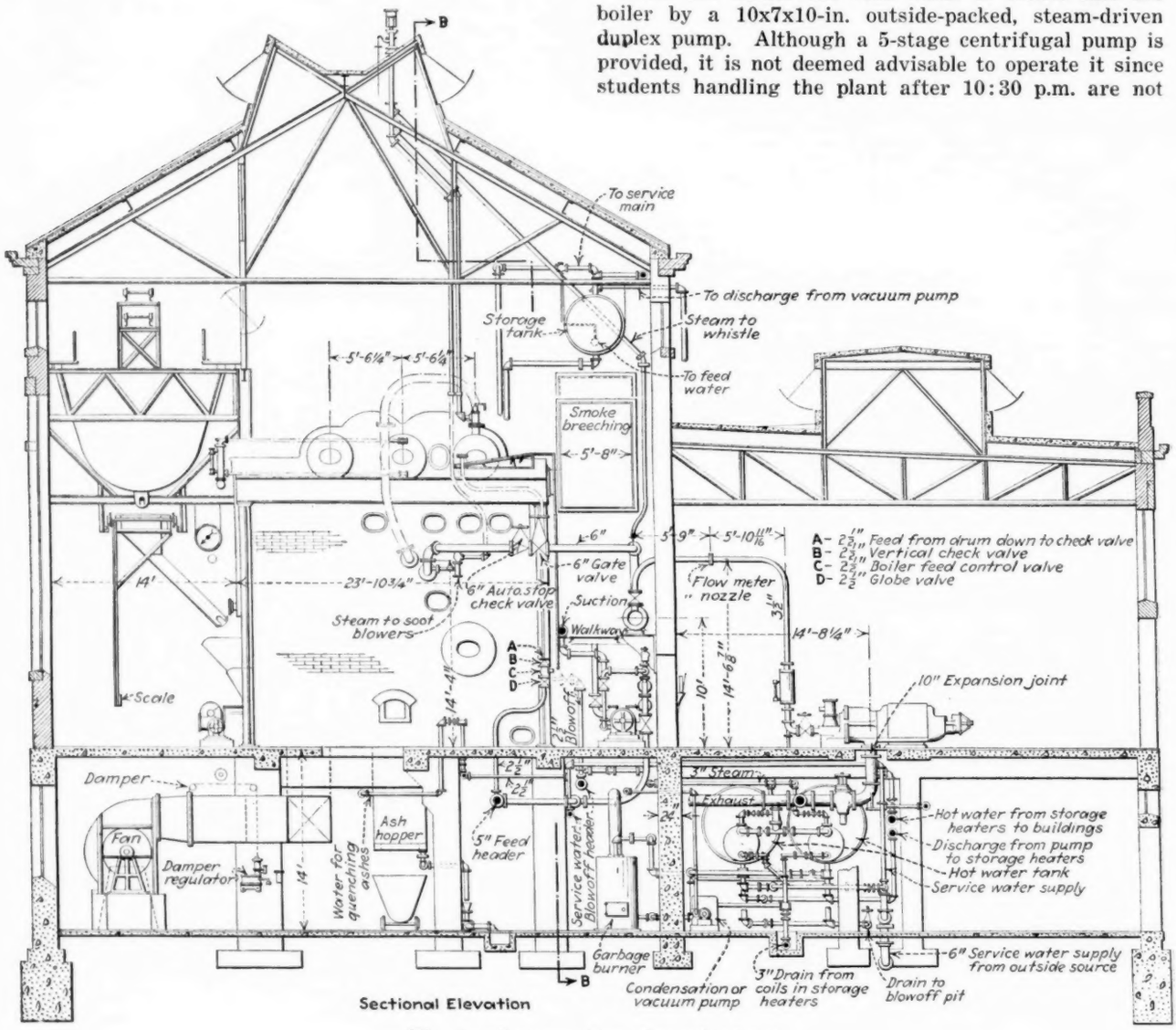


Fig. 8—Cross-section through plant

obtained from two tanks provided with steam coils. Part of the turbine exhaust enters these coils, the condensate being handled by a trap. The water is obtained from the city mains and after being heated is forced through the hot-water lines to the buildings by one of two motor-driven centrifugal pumps. Originally, these pumps were connected to the hot-water return lines, but it was found that they built up a pressure in the apparatus is shown in Fig. 5, which also shows the steam-flow meter connections to the turbine steam line.

Coal is received in hopper cars and dumped through a trestle into a hopper. From this an inclined apron conveyor carries it into a compartment at one end of the building and dumps it into the crusher. From the crusher it is lifted by a bucket elevator and conveyed to the bunkers placed above the firing isle. The ele-

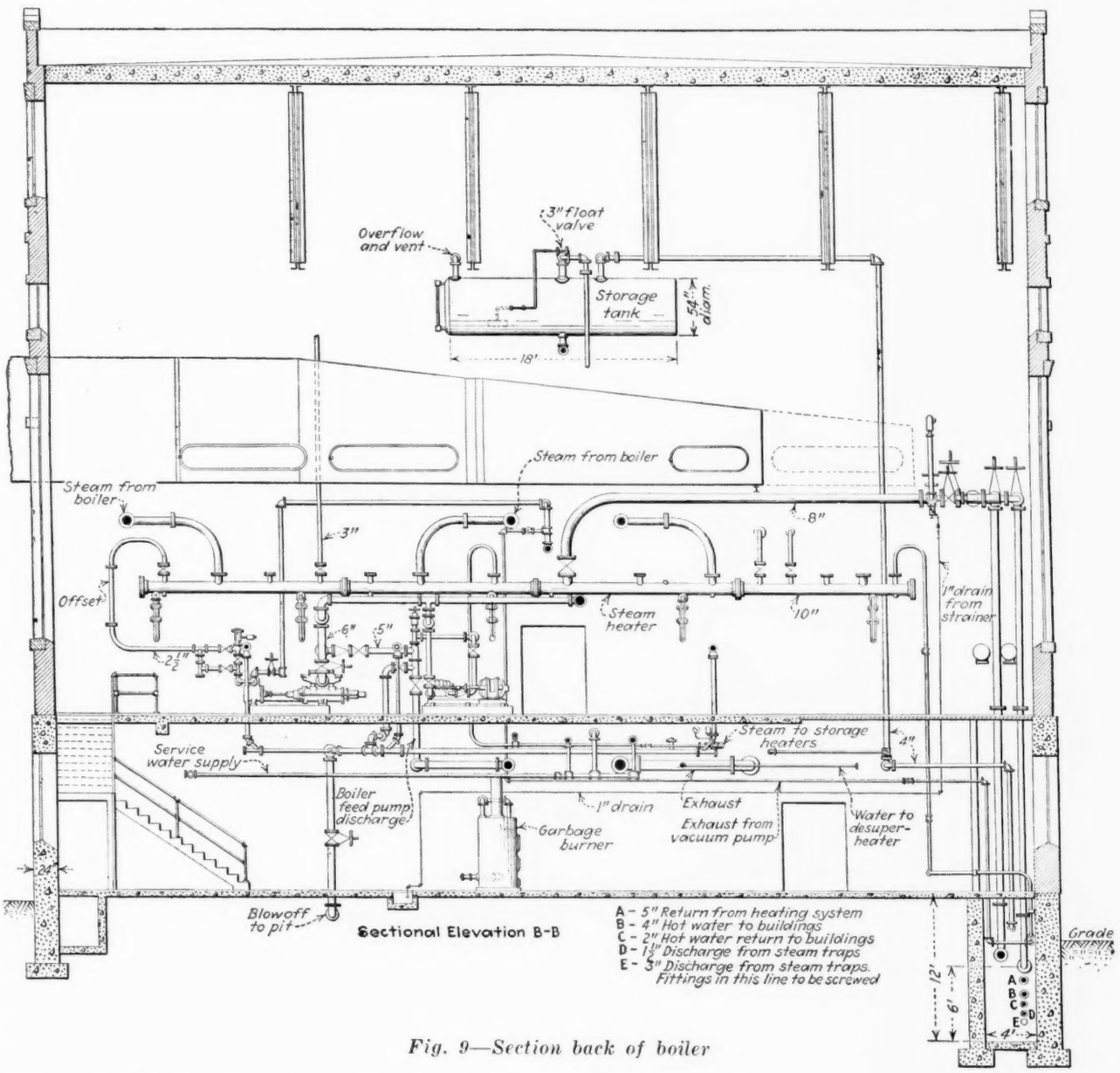


Fig. 9—Section back of boiler

tanks such that the city water could not enter. The change to the discharge side of the system eliminated this difficulty. A live steam connection is made with the heating coils and a thermostatically operated valve admits live steam at times when the turbine is idle.

The high-speed engine moved from the old building was built for saturated steam at 125 lb. The high pressure carried in the new plant necessitated the placing of a reducing valve in the line to the engine and the addition of a safety valve between the reducing valve and the engine throttle. To eliminate the superheat, a desuperheater was installed. The assembly of this vator has a capacity of 20 tons per hour, while the bunkers hold 150 tons of coal. Ashes are dumped into a car in the basement and rolled along a track to the outside ash dump.

The building is of brick with steel roof members upon which rests a concrete roof. The stack is of tile, 175 ft. high and with an inside diameter of 8 ft. at the top.

The plant is unusually well equipped with instruments. Each boiler is fitted with a steam-flow meter, draft gage, superheater thermometer and flue-gas-temperature recorder. In addition, steam-flow meters are

placed in the turbine line and in the two steam mains to the buildings. The coal is weighed, and at the end of each day the evaporation is calculated and the steam supplied to the various services noted. The cost of operating the plant is worked out each day on the basis of kilowatt-hours generated and pounds of steam made.

The boilers are operated 24 hours daily during the heating season, after which they are shut down and the hot-water service obtained from the garbage boiler shown in Fig. 9 in the boiler-room basement. The generating units are operated from 7 a.m. to 10:30 p.m. during the heating season, at other times outside current is used.

J. E. Sirrine & Co., Greenville, S. C., were the consulting engineers.

PRINCIPAL EQUIPMENT OF NORTH CAROLINA STATE COLLEGE POWER PLANT

Turbine capacity, kilowatts	200
Make	General Electric Co.
Generator characteristics	600 volts, 3 phase, 60 cycles.
Engine, bore and stroke, in.	13x12
Make	Skinner Engine Co.
Generator, make	Crocker-Wheeler Co.
Capacity, kw.	75
Exciter set, size, kw	10
R.p.m.	1,760
Make	General Electric Co.
Switchboard, make	General Electric Co.
Boilers, type	Inclined tube
Sq.ft. heating surface	Two 3,946 and one 2,340
Make	Babcock & Wilcox Co.
Steam pressure, lb. gage	175
Steam superheat, deg. F.	50
Stokers, type	Underfeed
No. retorts	2 and 4
Make	Combustion Engineering Corp.
Drive	Chain from 10-hp. motor
Make of motor	Westinghouse Elec. & Mfg Co.
Forced draft fan, make	American Blower Co.
R.p.m.	1,160
Motor, hp.	50
Motor make	Westinghouse Elec. & Mfg. Co.
Ash gates, make	Allen-Sherman-Hoff
Boiler Feed Pump, size	10x7x12
Type	Outside packed duplex
Make	Dean Bros.
Boiler Feed Pump, type	5-stage centrifugal
R.p.m.	1,750
Make	Dayton-Dowd
Motor	40-hp. Westinghouse
Heater, make	Cochrane Corp.
Damper regulator	A. W. Cash Co.
Soot blowers	Diamond Power Specialty Corp.
Feed-water regulators	Northern Equipment Co.
Blowoff valves	Yarnall-Waring Co.
Safety valves	Ashton Valve Co.
Non-return valves	Schutte-Koerting
Bunkers	Stearns
Coal Conveyor	Stearns Co.
Breeching	R. D. Cole
Stack, size ft.	175x8
Make	Rust Eng. Co.
Vacuum pumps, make	Nash Eng. Co.
R.p.m.	1,750
Drive	7½-hp. 550-volt motor
Hot-water pumps, make	Dayton-Dowd
R.p.m.	1,740
Drive	5-hp. motor
Hot-water tanks, make	Whitlock Coil Pipe Co.
Steam flow meters	General Electric Co.
Recording instruments for steam pressure and temperature, flue-gas temperatures, and hot-water temperatures	Brown Instrument Co.
Traps	V. D. Anderson Co.
Piping	Grinnell Co.
Valves	Chapman Valve Mfg. Co.

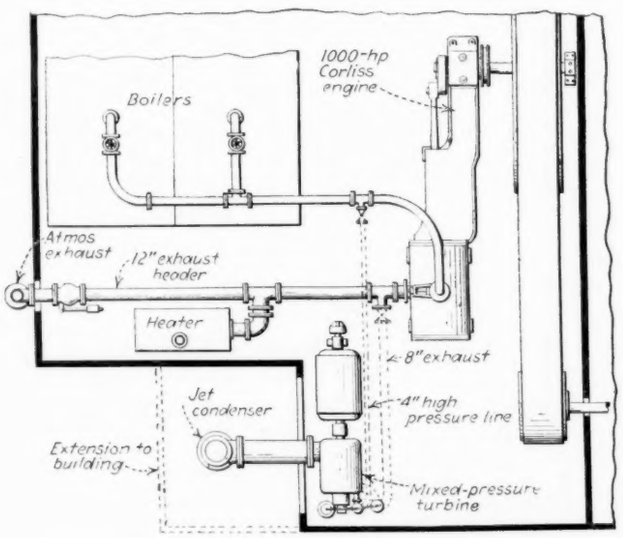
BEFORE USING PAINT or other coating inside or outside of stack breechings, the surfaces should be scraped and cleaned with a wire brush to remove dirt and soft iron rust. No paint should be used on the interior of the flue, as dust remaining in crevices is not likely to be thoroughly brushed into the paint, and cavities may remain uncoated. After cleaning, the best protective covering for the interior is a wash of portland cement and water, mixed to a consistency of cold-water paint and applied with a stiff brush. The outside of the flue should be painted with an asphaltic or a graphite paint, well filled into the joints to prevent rusting at the laps from infiltration of moisture from the atmosphere. The life of the flue will be greatly prolonged if it is protected from rain and snow.

Mixed-Pressure Turbine Saves $6,000 a Year

Power Formerly Purchased Is Now Generated from Exhaust Steam Heretofore Blown to the Atmosphere

BY WALTER ARNOLD*

AT THE PLANT of the Pearson & Ludascher Lumber Co., Philadelphia, power for driving the principal machines is furnished through a line shaft that is belt driven from a 1,000-hp. Corliss engine. Other machines that must necessarily be located at different points throughout the yards, such as unloading cranes at the docks, lumber hoists and cut-off saws, are



Arrangement of units in plant, showing extension made to building and piping

motor driven, the motors used ranging from 10 to 85 hp., giving a total connected load of approximately 300 hp.

Previously to 1925 the current for driving all motors and lights was purchased from the public service company, the average monthly consumption for 26-day period being around 5,700 kw.-hr., which gave an average power bill of about $500 per month.

Steam for the plant is supplied by 2,500-sq.ft. water-tube boilers at 130 lb. pressure, and the fuel used is sawdust and refuse from the planers. The supply of this fuel, which is delivered directly to the boiler room by a blower, is slightly more than that required to produce the necessary steam. Therefore no other fuel is used. The fuel costs practically nothing beyond a little handling.

As the engine was operated non-condensing against 2½ lb. back pressure, it was decided early in 1925 to utilize the exhaust steam to generate current with which to supply the various motors, thereby reducing materially the monthly bill for purchased current.

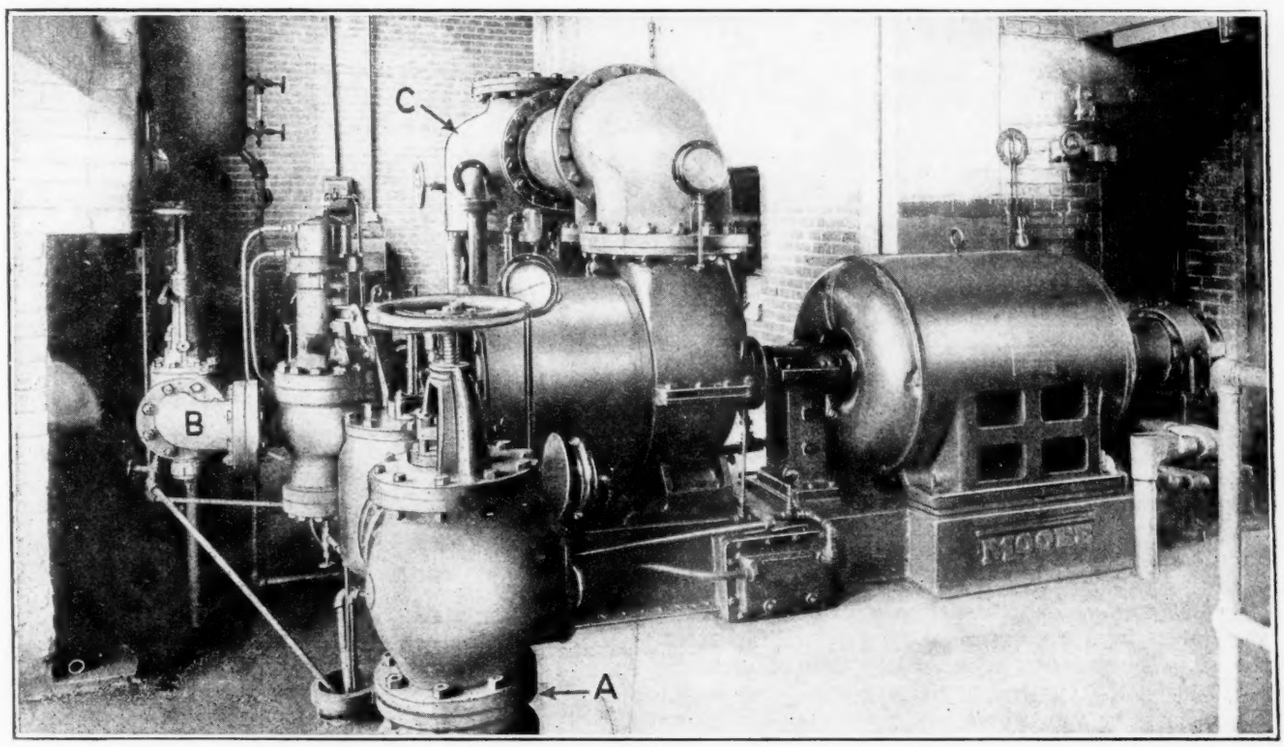
A check was first made of the average load on the engine and from this the total steam delivered per hour was estimated. An analysis was also made of the power required by the motors, which necessarily varied over a wide range due to the intermittent character

*Chief Engineer, Pearson & Ludascher Lumber Co.

of the load on practically all of the motors, which the possible exception of the 30-hp. motor driving the refuse blower. With the survey of the exhaust-steam flow and the electric-power consumption completed, it was apparent that a unit around 200 kw. would meet the power requirements.

The type of unit finally selected was a Moore mixed-pressure turbine designed to operate either on high-pressure steam at 130 lb. or low-pressure steam between 2½ lb. above atmosphere to 28 in. vacuum, direct connected to a 187-kw., three-phase, 60-cycle, 3,600-r.p.m., 440-volt Allis-Chalmers generator with exciter. The unit is served by a Schutte & Koerting multi-jet condenser placed close to the turbine and fitted with a vacuum breaker and all the necessary protective devices.

The idea of installing a mixed-pressure turbine was due to the fact that the generation of power would not be dependent upon the operation of the Corliss engine. In other words, when the Corliss engine is shut down, as it would be after hours or during holidays, and power might be required for cranes, motors, etc., the turbine is then operated on high-pressure steam. Under all conditions the turbine operates condensing. Demands have been made on the unit for 100 per cent overload for long intervals, and the unit has met this service satisfactorily. The condenser also has handled the steam without the breaker going out.



Mixed-pressure turbine of 187-kw. capacity with jet condenser

A—8-in. exhaust steam connection; *B*—4-in. high-pressure steam connection; *C*—multi-jet condenser

As will be seen from the plan depicted herewith, only a small extension was necessary to the building and a few short runs of 4- and 8-in. pipe connected the high-pressure and exhaust steam to the turbine. These extensions are indicated by dotted lines.

There is a 12-in. exhaust header coming from the Corliss engine, and this has sufficed as a receiver between the engine exhaust and the turbine throttle. In fact, the low-pressure steam flow to the turbine, is practically devoid of pulsations and the governor shows no variation to speak of.

The injection water is supplied by a 1,000-gal-per-minute centrifugal pump, motor driven, located at the river bank, a distance of about 1,000 ft. from the turbine. The pipe line through which the injection water is carried was formerly used for the general water supply for the plant. During the winter months, with about 40 deg. injection water, the vacuum obtained is around 29.6 in.

The total cost of the unit, including cost of installation, condenser, foundations and extension to piping and building, was approximately $12,000, exclusive of the pipe line to the river.

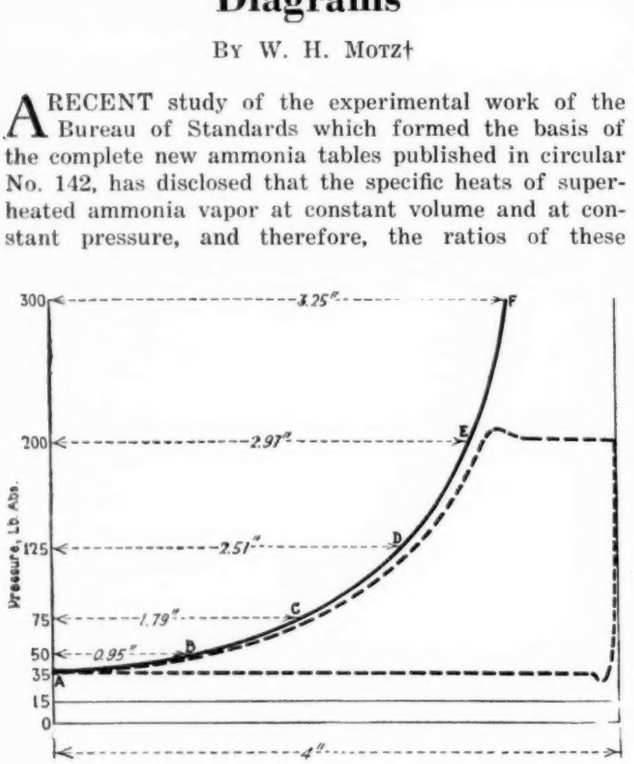
The operation of the mixed-pressure valve is such that the steam at the throttle may be changed from high-pressure to low-pressure at will, and the mixed-pressure valve automatically takes care of this situation. The turbine is further equipped with nozzle control so that full load requirements may be met with a decreased boiler pressure. There are doubtless many industrial power plants where steam now being wasted might be employed to generate needed power.

It is a wrong idea to think that an inferior oil copiously applied to the cylinders of a Diesel engine will do as well as a good oil. In fact it is poor policy to feed more lubricating oil, even of the best grade, to the power cylinder than is absolutely necessary. Too much oil will gum up the piston rings and will cause oil to drip from the liners. This oil, having been subjected to heat, is contaminated by carbon, which thus finds its way into the crankcase. This should be avoided as much as possible.

Analyzing Ammonia Compressor Diagrams*

By W. H. Motz†

A RECENT study of the experimental work of the Bureau of Standards which formed the basis of the complete new ammonia tables published in circular No. 142, has disclosed that the specific heats of superheated ammonia vapor at constant volume and at constant pressure, and therefore, the ratios of these



Construction of theoretical compression line

specific heats, vary considerably with the temperature and pressure of the ammonia. This being the case, the use of the standard formula for a perfect gas, pv^k = a constant, to lay out a theoretical adiabatic compression curve for comparison with the actual diagram taken from a compressor, is somewhat in error. Instead of assuming constant values for the exponent k of 1.28 or 1.30, as has been the custom, the actual values should be substituted, and these may vary from 1.26 to 1.3 over the usual range of operating pressures.

With this in mind the author has developed a new method of laying out the adiabatic compression curve which will give the correct location of points on the compression curve to show the relation of pressures and volumes of the ammonia under actual working conditions, but compressed adiabatically. The various values of pressures and volumes were taken directly from the new Bureau of Standards' tables. The method is perhaps best illustrated by the following example:

Assume that the pressure at the beginning of compression is 35 lb. abs. and that the temperature of the ammonia vapor is 50 deg. F.; that the compression pressure is 170 lb. abs., and the compression adiabatic. From the superheated ammonia tables it will be found that the entropy of the vapor at 35 lb. and 50 deg. F. is 1.3756, and the specific volume of the vapor is 8.895 cu.ft. per lb. Now, after adiabatic compression, the pressure is 170 lb., but the entropy is 1.3756. By interpolation it will be found that the volume at this point is 2.593.

Now, it may be assumed that the ammonia compressor cylinder holds just 8.895 cu.ft. at the beginning of compression. The percentage of displacement required to compress the vapor to 170 lb. is found as follows:

$$\frac{8.895 - 2.593}{8.895} = 0.708 = 70.8$$

It is evident that the point thus located represents the piston movement in percentage of reduction of the total inside volume of the cylinder. If the cylinder has no clearance, the point so located represents the percentage of reduction of the stroke volume. In a cylinder containing clearance, a point thus located would represent the percentage of reduction of stroke volume plus the clearance volume.

The accompanying table has been prepared by the author from the Bureau of Standards ammonia tables

VOLUME REDUCTIONS DUE TO ADIABATIC COMPRESSION OF AMMONIA

Abs. Suction Press.	Adiabatic Compression Pressures, Lb. Absolute 25	35	50	75	125	200	300
15	0.324	0.480	0.606	0.715	0.808	.....	.....
16	0.291	0.453	0.585	0.703	0.798	.....	.....
17	0.255	0.426	0.565	0.684	0.791	0.855	.....
18	.....	0.401	0.546	0.671	0.778	0.850	.....
19	.....	0.375	0.527	0.667	0.770	0.843	.....
20	.....	0.351	0.506	0.641	0.760	0.834	.....
21	.....	0.324	0.487	0.626	0.750	0.829	.....
22	.....	0.302	0.469	0.613	0.743	0.821	.....
23	.....	0.277	0.451	0.601	0.734	0.816	.....
24	.....	0.252	0.433	0.586	0.723	0.810	.....
25	.....	0.229	0.413	0.573	0.715	0.800	.....
26	.....	0.205	0.396	0.560	0.705	0.797	.....
27	.....	0.183	0.382	0.540	0.697	0.790	.....
28	.....	0.157	0.360	0.532	0.688	0.788	.....
29	.....	0.133	0.342	0.519	0.678	0.780	.....
30	.....	.....	0.328	0.507	0.671	0.775	0.836
31	.....	.....	0.308	0.485	0.662	0.769	0.831
32	.....	.....	0.292	0.482	0.654	0.761	0.828
33	.....	.....	0.275	0.469	0.645	0.757	0.824
34	.....	.....	0.257	0.457	0.638	0.750	0.819
35	.....	.....	0.238	0.448	0.629	0.743	0.813
36	.....	.....	0.224	0.433	0.619	0.738	0.810
37	.....	.....	0.207	0.421	0.610	0.734	0.806
38	.....	.....	0.190	0.408	0.603	0.726	0.802
39	.....	.....	0.175	0.397	0.596	0.721	0.797
40	.....	.....	0.156	0.385	0.587	0.716	0.794
42	.....	.....	0.127	0.362	0.572	0.704	0.787
44	.....	.....	0.094	0.336	0.555	0.693	0.778
50	.....	.....	.....	0.269	0.510	0.660	0.753

to give the percentage of volume reductions during adiabatic compression, in decimal fractions of the total volume. Values are given for compression to pressures of 25, 50, 75, 125, 200 and 300 lb. abs. and for absolute initial or suction pressures varying from 15 to 50 lb. An allowance has been made for the superheating action of the cylinder on the vapor during the suction stroke.

The practical use of the foregoing data in the laying out of an adiabatic compression curve on an indicator diagram is shown in the illustration. The dotted lines represent the original diagram, which shows that the initial pressure is 35 lb. abs. at point *A*. The length of the diagram representing the stroke volume, is taken as 4 in. The horizontal distances measured from a vertical line through point *A*, representing the relative reductions of volume or piston travel for compression to 50, 75, 125, 200 and 300 lb. abs. pressure, may be found as follows from the data given in the table:

Compression Pressures	Percentage Volume Reduction from Table	Length of Diagram, In.	Horizontal Distance to Point on Curve, In.
50	0.238	4	0.95
75	0.448	4	1.79
125	0.628	4	2.51
200	0.743	4	2.97
300	0.813	4	3.25

In other words the horizontal distance to the point on the curve for specific initial and compression pressures

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†Technical engineer, Hill Manufacturing Co., Chicago, Ill.

is obtained by multiplying the percentage volume reduction by 4, the latter figure being the length of the diagram.

Where clearance is involved, the multiplying factor is the length of the diagram plus an additional amount in proportion to the clearance.

Thus the method requires only the multiplication of factors from the table by the length of a line proportional to the total cylinder volume. For the particular pressure involved, the result is the horizontal distances from a vertical line through the toe of the diagram to the point on the adiabatic compression curve. These horizontal distances may be set off by a scale reading in hundredths of an inch, and the various pressures may be set off on the vertical line by a ruler having the same scale as that of the spring used in the indicator.

Inasmuch as the foregoing is based on the United States Bureau of Standards ammonia tables and as the labor required has been reduced to a minimum, the method is recommended to all who are required to analyze indicator diagrams from ammonia compressors.

The Overworked Chimney

Increasing CO_2 Adds To Its Capacity

BY CHARLES C. PHELPS

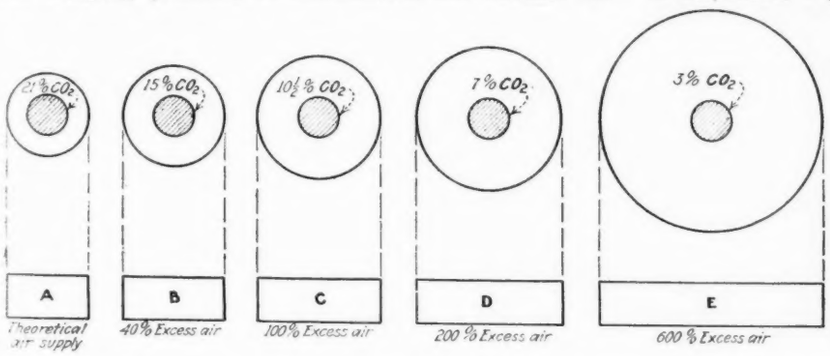
INNUMERABLE articles on boiler economy have dealt with the fuel-saving possibilities of high CO_2 in the escaping products of combustion, but another important benefit to be derived from improving the CO_2 has scarcely been touched upon; namely, its effect upon the capacity of the chimney.

Increasing the CO_2 materially increases any chimney's capacity. Sometimes a plant finds itself in the predicament of urgently needing more chimney capacity, but is unable to proceed with the construction of a new chimney for financial or other reasons. In such cases increasing the CO_2 may solve the chimney problem, in addition to cutting down the fuel bill materially.

In considering this subject, it should be kept in mind that high CO_2 implies a relatively small volume of flue gas and consequently a smaller burden on the chimney. For a given rate of fuel consumption, the gas volume is approximately inversely proportional to the percentage of CO_2. As an example, with 12 per cent there would be about one-half as much flue gas per pound of fuel burned as with 6 per cent.

For each pound of carbon in the fuel burned, there are $3\frac{2}{3}$ lb. of carbon dioxide in the flue gas, irrespective of the amount of air used, assuming complete combustion without the formation of any CO. The shaded portions of the cylinders in the diagram represent the volumes of CO_2 produced from a pound of carbon burned with different quantities of air. These volumes are always the same, being $3\frac{2}{3}$ lb. in weight. If it were possible to burn the carbon completely with no more than the theoretical amount of air, then all the oxygen in the air would be converted into CO_2 and it would constitute 21 per cent by volume of the flue gas while nitrogen would constitute the balance of 79 per cent. This is illustrated by cylinder *A*. If the air supply were doubled (100 per cent excess air), the CO_2 would then occupy relatively half as much of the total volume of flue gases, that is, $10\frac{1}{2}$ per cent. The unused oxygen would also occupy $10\frac{1}{2}$ per cent of the volume, while nitrogen would occupy 79 per cent, as before. This is illustrated by cylinder *C*. Cylinders *B*, *D* and *E* are proportional to the volumes of flue gas generated for other proportions of excess air used in burning a pound of carbon.

It is obvious that with a chimney of given diameter, much more draft would be required to carry away the quantity of flue gas represented by cylinder *E* in a given period of time than would be the case with the gas volume represented by any of the others. Likewise, the gas represented by cylinder *A* would require the least draft to carry it away through a given size chimney in unit time. If, however, the cross-sectional chimney area be decreased at the same rate that the gas volume is decreased, a given available draft would handle the gas with equal speed in all cases, neglecting loss of draft due to chimney friction and flue-gas temperature which, generally speaking, would increase somewhat as the CO_2 is reduced.



The circles represent relative flue-gas volumes with varying CO_2 for unit fuel consumption. They also represent minimum relative chimney size required for each condition under fixed available draft

It can therefore be assumed that, with a fixed available draft as determined mainly by chimney height, the chimney cross-sectional areas would have to be proportional to the circles in the diagram in order to provide sufficient capacity to carry away flue gases as represented by corresponding cylinders. In other words, if a chimney of a size represented by *D* is just able to remove all the gas containing only 7 per cent CO_2, from a furnace burning one ton of fuel per hour, then with the same available draft it would be unable to remove all the gas represented by *E*. However, with the same available draft the same chimney would be able to carry away all the $10\frac{1}{2}$ per cent CO_2 gas *(C)* from a furnace that burned even more fuel. In fact, the chimney could handle the gases even if 50 per cent more fuel were burned per hour, because the volume of gas from $1\frac{1}{2}$ tons of fuel with 100 per cent excess air would be the same as that from one ton of fuel burned with 200 per cent excess air.

An analysis of coal giving the percentages of moisture, volatile, fixed carbon and ash is called a *proximate* (not *approximate*) analysis, as distinguished from an *ultimate* analysis that gives the percentages of the various chemical elements, carbon, oxygen, hydrogen, etc. The former type of analysis is much easier to make.

Alternating-Current Motors—Stator Construction

How the Rotor and Stator Cores Are Built—Types of Stator Frames—Types of Slots and Slot Insulation—Type of Coils and Their Insulation—Special Features of Construction and Ventilation

By B. A. BRIGGS

INDUCTION motors have come to be the most popular of all types of general-service motors. Although the squirrel-cage type is inherently a constant-speed machine, it has been adapted to a wide variety of applications. Its simple and substantial construction has from the motor's inception attracted to it a great deal of attention. Much of this effort has been devoted toward making the motor trouble-proof. Simple as the

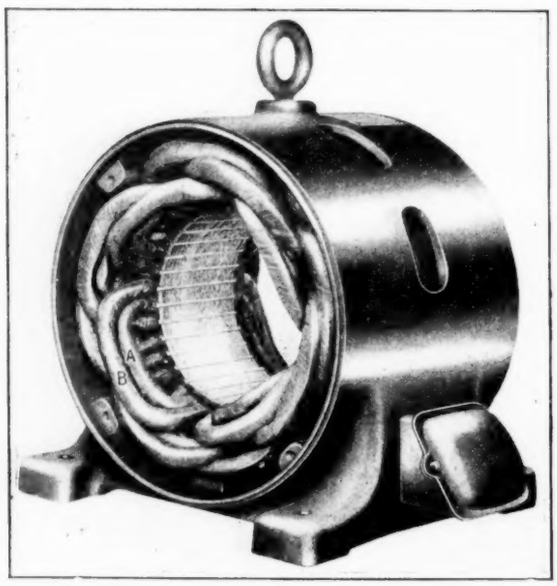


Fig. 1—Core-frame type stator with concentric-type winding

design is, this type in the earlier forms gave considerable trouble, due to failures of the stator windings from various causes and also the rotor-bar connections to the end rings worked loose and interfered with satisfactory operation. To overcome these defects a large variety of different construction details are to be found in a comparison of the motors put out by various electrical manufacturers.

In both the squirrel-cage type and the wound-rotor types of induction motors the stator frames and windings are similar, although they vary in detail with different manufacturers. In general, the polyphase induction motor is built for two- and three-phase circuits and is the type that will be discussed in this article. The stator frames are built in three general forms—core frame, skeleton frame and riveted frame—and the windings used may be either of the concentric or the distributed type. Fig. 1 shows a Century Electric Co. core-frame or box-frame type stator with a pyramidal or concentric winding. The frame is of cast iron ribbed on the inside to give added strength and to provide free circulation of air around the windings and core. On the inner surfaces the ribs are machined for the reception of the laminated-steel core.

After stamping, the steel laminations are annealed and assembled into the frame between two retaining rings. One of the rings is cast to the frame, and the other is locked into place to hold the laminations under heavy pressure. On account of the alternating magnetism set up by the current it is essential that the core be held under heavy pressure if the motor is to operate quietly. In the figure the core is shown to be solid for the full width of the face. For the larger

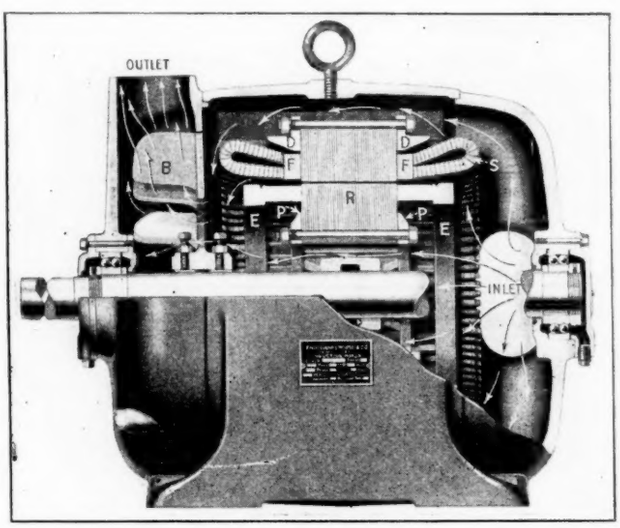


Fig. 2—Section through totally inclosed induction motor

machines, one or more ventilating ducts are provided by using one or more laminations with radial fins. In some manufacturers' construction the radial fins are riveted to the laminations and in other constructions they are spot welded. These fins act as spacers to form the ducts between the sections of the core.

The Fairbanks, Morse Co. totally inclosed motor shown in section, Fig. 2, gives a good idea of its general construction. This motor is of the totally inclosed forced-ventilated type for use where motors are installed in very dirty places or where they are subjected to destructive fumes, excessive humidity and temperatures.

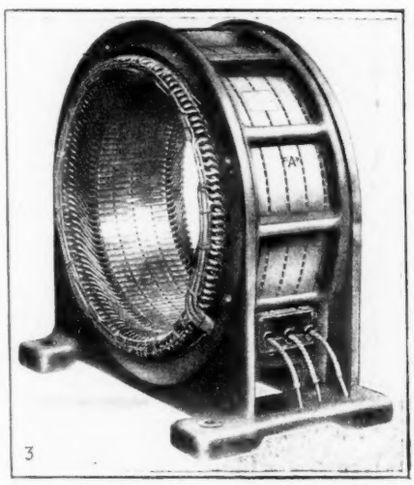
The air inlet may be connected by a pipe to a location where clean air will be obtained. The air is drawn through the motor by a fan *B*, which is held to the rotor shaft by setscrews. How the air flows through the center of the rotor core, the air gap between the rotor and stator and around the outside of the stator coils and core is indicated by the arrows. This air, after passing through the fan, is discharged at the outlet, which may open into the room or be connected to discharge outside of the room as desired.

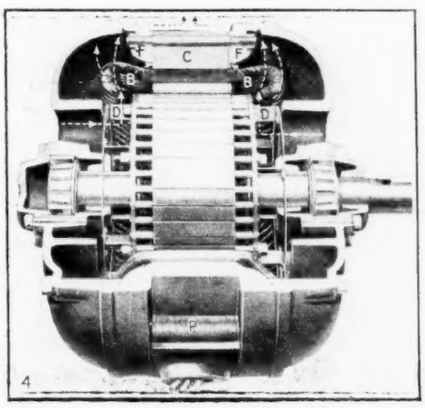
In this particular motor the rotor core *R* is assembled on a cast-iron spider which is keyed to the shaft. The core laminations are of annealed electric steel and japanned on both sides to minimize the core losses. These laminations, after assembly on the spider, are tightly compressed and clamped securely between the two end plates *P* by bolts, one of which is shown at the bottom of the core. In the smaller-sized machines the core is assembled directly on the shaft and keyed. In either case the shaft can be removed and replaced if necessary. The rolled-copper bars which form the rotor windings are driven into the slots and the end rings *E* are cast on. This part of the construction will be given further consideration in another article.

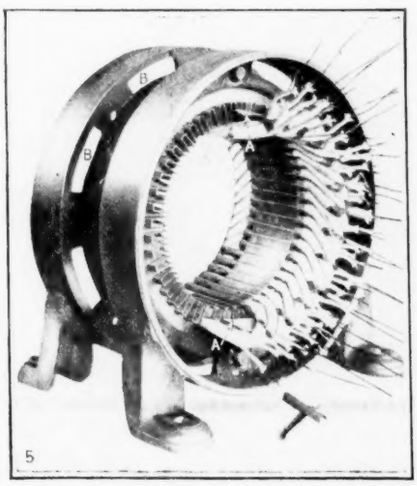
End rings *D* and *D* support the stator-core laminations and are held under heavy pressure by a number of bolts, one of which is shown at the top of the core. The core is carried on ribs cast integral with the frame. These ribs allow ample space back of the core for the free circulation of air to carry away the heat generated in the windings. The stator winding *S* is insulated in the slots with fiber, which can be seen extending beyond the core at *F*. A more detailed description of the stator winding will be given subsequently.

Instead of completely surrounding the core by a frame, as in Figs. 1 and 2, it may be supported in a structure as in Fig. 3, which shows a General Electric skeleton-frame type stator. In this construction all superfluous metal has been cut away, leaving only the ribs and end rings of the frame for supporting the core. This type of construction has resulted in a frame that is stiff and rigid with considerable reduction in weight. The stator core is keyed to the frame ribs and held at each end by iron rings secured to the frame. The air ducts in the core can be seen at *A* and the metal spacers, which are spot welded to a lamination on one side of the air duct, are clearly visible.

A third type of stator construction is that shown for an Allis-Chalmers motor, Fig. 4. This construction is known as the riveted-frame type, in which the stator core forms part of the frame. In building up the stator core *C*, the laminations, after being japanned, are assembled on a mandrel and while subjected to hydraulic pressure are clamped and riveted together between two cast-steel end frames *F*. One of the rivets can be seen near the top of the core. These rivets are a driving fit into the holes in the laminations. The holes are in projecting ears on the laminations, and the latter are of ample size and number to prevent distortion of the core. One of the projections is shown at *P*. These







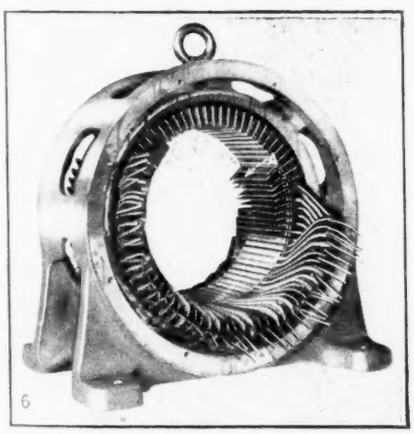


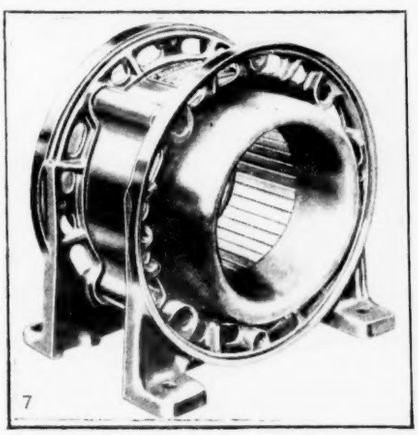
Fig. 3—Skeleton-type stator frame

Fig. 4—Section through riveted-frame type motor

Fig. 5—End rings for riveted-frame made from angle iron by welding

Fig. 6—Stator core with open-type slots partly wound

Fig. 7—Ends of stator windings incased in insulating compound



projections on the outside of the core allow placing the end frames far enough outside the core to permit providing openings in these frames for the circulation of ventilating air, similar to those shown at *B*, Fig. 5. The ventilation of the machine is accomplished by air drawn in through openings around the bearing hubs of the housings by shrouded fans *D* on the rotor. Passing through the fans, the air is blown around the ends of the stator coils and discharged through openings in the cast-steel end frames and across the back of the

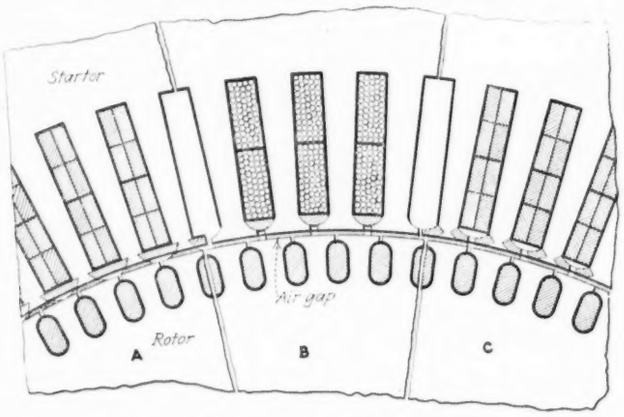


Fig. 8—Three types of stator-core slots

laminated core as indicated by the arrows. Between the core and end frames is placed a boiler-plate notched tooth support *B*, which extends up to the top of the core teeth between the slots and prevents the tooth laminations from being bent.

Instead of using cast-steel end frames as in Fig. 4, the Lincoln Electric Co. employs frames made up of standard angle-iron bent in a circle and welded, after which the feet, which are of drop-forged steel, are welded on to complete the frame. After the stator core is assembled, it is hot-riveted between the two end rings to hold the laminations tightly together and to prevent vibration.

Types of Slots Used

In the stator two types of slots are used, open, as shown at *A*, Fig. 8, and semi-closed, as at *B* in the same figure. With the semi-closed slots a better distribution of the magnetic field in the air gap is obtained as shown, and this results in a somewhat higher power factor, efficiency, starting torque and overload capacity. However, the use of this type of slot is generally limited to low-voltage machines of small capacity, due to considerations in the design of the winding. In the large-sized motors the semi-closed type of slot is not so vital a factor in efficient operation as in the small-sized machine, and this is another reason why the open-slot construction is generally used on the large-sized motors.

Two types of windings are used. The concentric or pyramidal style, Fig. 1, in which the coils making up a phase group, are concentrated one within the other as coils *A* and *B*. In this type of winding, coils of different sizes are required, depending upon the number of coils used in each group. At one time the concentric type of winding was used extensively, but the distributed type, as shown in Fig. 3, has come into general use. In this type a diamond-shaped coil of uniform size and shape is used. These can be better seen in the partly wound stator of a Westinghouse motor in Fig. 6. Where open-type slots are used, the coils are wound and formed and completely insulated before putting them into the slots. It is general practice after the coils have been shaped and taped to dip them in an oil-, acid- and moisture-resisting varnish and then bake them in an oven. This has the effect of sealing the wires together in a solid mass and prevents any movement between the wires.

For the semi-closed type, the coils must be put into the slots one wire at a time, and this precludes insulating the coils before putting them in place. The coils are wound and shaped, and after they are put into the slots the ends are insulated with tape, as in Figs. 1 and 5. In the double layer winding, such as shown in Fig. 5, an insulating strip is placed in the slot between the top and bottom sides of the coils and sheet insulation is threaded in between the top and bottom layer of the end windings. The end of this insulation can be seen at *A* in Fig. 5. Another insulation feature that is general practice is to place extra insulation on the coils between phases; either in the form of an additional layer of linen tape or a layer of varnished cambric on the coil before putting on the tape.

Dipping and Baking of the Winding

After the stator is wound, it is baked until all moisture is expelled and then placed in an impregnating tank and thoroughly saturated with insulating varnish, after which it is baked. The dipping and baking process may be repeated two or three times until the winding is thoroughly impregnated. When the windings are to be subjected to severe operating conditions such as operating for long periods in an atmosphere that is heavily laden with moisture, acid or alkali, or where graphite or metallic dusts are present, the end winding may be completely incased in an insulating compound

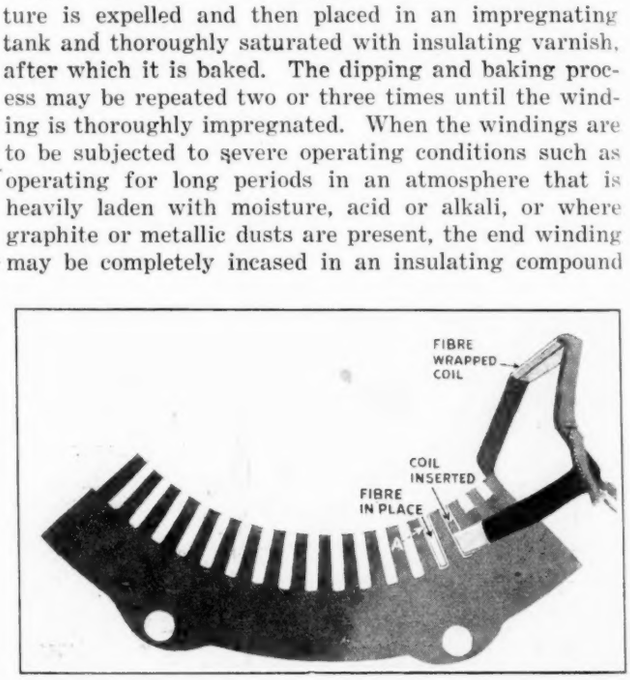


Fig. 9—Tooth ends overhang the slot insulation

as shown on the General Electric motor, Fig. 7. In addition to protecting the coils the surface of the insulation is smooth and easily cleaned.

Before the coils are placed in the stator slots, the slots are insulated. This insulation generally consists of sheet fiber or a sheet of varnished cambric between two sheets of fish paper or similar material. In many of the designs this insulation is cut to a width that will allow it to extend well above the tops of the slots, as shown at *A* in Fig. 6. After the coils are in place the excess insulation is cut off and the retaining wedge driven in above the coils.

With the usual type of open slots, the sides of the slots are straight for their full length, and the sides of the teeth are notched to hold the retaining wedges as shown on the left, Fig. 8. As a compromise between the open and the semi-closed slot on its large-sized motors, the Lincoln Electric Co. allows the top ends of the teeth to overhang the thickness of the slot insulation. The slot insulation is cut of such dimensions that it fits under the overhang or tang on the teeth, as at *A* in Fig. 9. The coils are formed in the usual manner, the slot section is insulated with a wrapping of fiber and hot-pressed. This brings all coils to the same dimensions and they fit tightly in the slots. The tang or lip on the teeth not only serves to hold the retaining wedges, but also gives a better flux distribution in the air gap between the stator and rotor core.

With the open slots the stator coils can be made up and completely insulated and impregnated before putting them in the slots. This type of slot also makes it possible to remove a damaged coil and replace it without completely rewinding the motor. As already pointed out, the open slot does not give as good a distribution of the flux in the air gap as is obtained with the semi-closed slots as indicated in Fig. 8, *A* and *B*.

Use of Magnetic Slot Wedges

To combine the advantage of the open and semi-closed slots in the one machine, the Crocker Wheeler Co. uses slot wedges made of magnetic material, as shown in Fig. 8 *C* and Fig. 10. The latter shows a section of a stator core and embraces three slots and sections of the coils. These magnetic wedges *A* are driven in the grooves in the teeth the same as wooden or fiber wedges are, but are insulated from the teeth with sheet fiber to prevent short-circuiting the lamination and increasing the eddy-current losses. The slots shown in the center of the magnetic bridges are to prevent short-circuiting the slot magnetically. The narrow strips holding the two sides of the bridge together become saturated and limit the amount of flux that may pass across the slot in this part of the bridge.

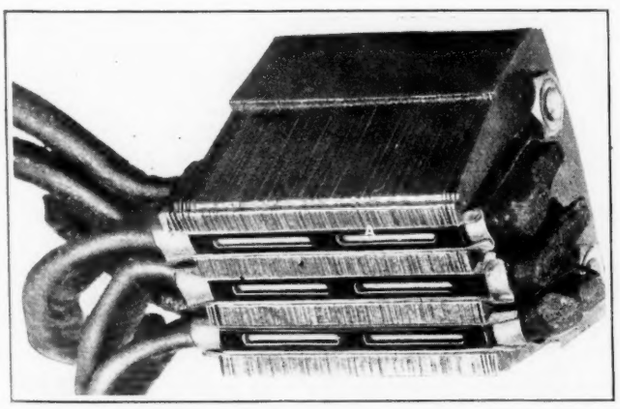


Fig. 10—Section of stator using magnetic slot wedges

Fig. 11 shows the method used by the Howell Electric Motors Co. to insulate the stator coils in the slots. The thickness of the insulation has been shown greatly enlarged to bring out the different layers, but the dimension values give the true thickness in decimals parts of an inch. The slot insulation consists of a layer of varnished muslin between two layers of heavy tough tan paper arranged as in the figure. It will be noted that the paper doubles back over the ends of the varnished muslin and laps at the bottom of the slot. This slot insulation does not extend beyond the tooth ends during winding, as is done with some other types of construction, but fits down into the slot under the lips of the teeth as shown in the figure.

The wire used in the coils is enamel and double-cotton insulated. The enamel gives the wire a hand-glazed surface, which has a high dielectric strength, and the double-cotton gives additional insulation and mechanical strength to the covering when impregnated with insulating compound. After the first coil is placed in the slot, a strip of fiber is put on top of it to give added insulation between the coils. Before the top coil is put into the slot, a sheet of varnished muslin is put in, and after the coil is in place the end of the muslin overlaps on top of it. A strip of horn fiber is placed on top of the coil and the fiber retaining wedge driven under the lips of the teeth to hold the coils firmly in the slot. To simplify the diagram, the winding spaces are shown only partly filled with conductors.

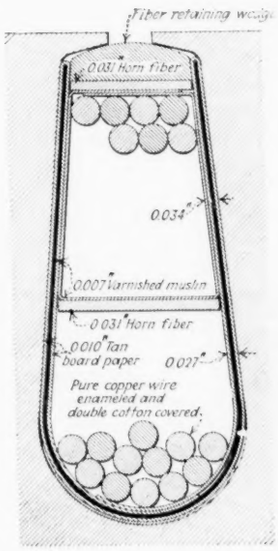


Fig. 11—Assembly of insulation and windings in the stator slot

The insulation is allowed to extend beyond the ends of the slots to protect the coils from injury where they come out of the slots. The coil ends are taped up to each slot, and oiled duck is used as insulation on the phase coils. After being heated and dipped in insulating compound, the stator is thoroughly baked.

In the foregoing, although the different types of construction have referred to specific manufacturers' equipment, they are in many cases common in a greater or less degree to the products of a number of motor builders.

Downward flow of the weak liquor in an absorber is the most satisfactory, for the same reasons that in condensers the ammonia flows downward. Weak liquor of, say, 22.5 per cent ammonia content, rapidly absorbs the gas supplied by the brine cooler, to become enriched to, say, 34.3 per cent. This rapid absorption causes foam, and if the aqua in a 10-pipe high absorber flows upward, the action is not steady. Unless the strong liquor receiver is extra large, the pump will pump gas instead of liquor and will slow down, interrupting the supply of strong liquor to the generator, where more vapor will be boiled off. The heat of absorption can be removed by cooling water flowing counter-current to the liquor. In atmospheric absorbers, where water is showered over the outside, the flow of liquor should be upward for the sake of securing counter-current.

The pilot cell in a storage-battery installation is no different from other cells, but is one selected for convenience of location, and used to indicate the battery's general condition.

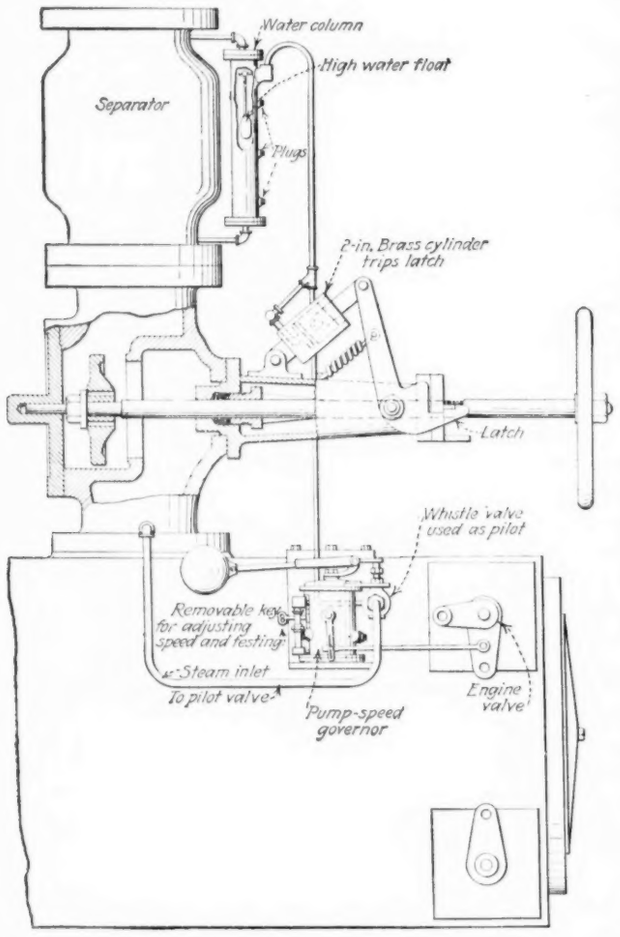
Engine Safety Device

Eliminating Overspeed and Water Hazard from Steam Engines by the Use of Ordinary Commercial Equipment

By E. E. Clock

Chief Inspector, Steam Turbine and Engine Dept., The Fidelity & Casualty Company of New York

THE accompanying drawing shows that it is easy to equip an engine so that it cannot overspeed or be flooded and so that the speed limit can be tested at will without taking the engine out of service. All the necessary equipment is obtainable in the open market.[1] The



Either high water in the separator or overspeed will admit steam to the 2-in. brass cylinder and trip the throttle valve

parts required are: A quick-closing throttle valve; a pump speed regulator; a ¼-in. single-seated whistle valve to be attached to the regulator and used as a pilot valve; some reliable water column (discarding the gage glass, trycocks, whistle, and low-water-alarm float, but retaining the high-water-alarm float and valve).

The throttle must be slightly changed from the stock design in the unlatching gear, but the attachment of the 2-in. brass cylinder costs no more than the equipment that is discarded. The cylinder should be piped with a release cock at the bottom to allow the piston to be pushed back into place, and the sides of the cylinder should have a number of holes drilled through at the upper travel limit of the piston so that it cannot be pushed out of the cylinder. The pipe from the pilot valve and the one from the whistle opening of the water column may be branched together and carried as one to the brass cylinder for unlatching the throttle.

The operation of the device is as follows: Any speeding up of the "pump-speed" regulator will open the pilot valve attached to it, admitting steam from below the throttle to the 2-in. cylinder attached to the unlatching gear. In the same manner the raising of the float in the water column will operate the unlatching gear. This float might well be placed even lower than shown in the drawing.

A slight turn of the adjusting key on the side of the regulator will lower the speed setting slightly below normal. This will trip the throttle, indicating that the apparatus is in working condition. By blocking the throttle from going all the way shut, the overspeed trip may thus be tested with the engine in service. When not testing, the key should be removed to prevent meddling.

Some of the advantages of this device are: It is so situated as to avoid the danger of being injured by faulty belts; it is not in or near the center of the wheel (the suction point for all the flying dirt and grease in the plant); it is reliable, sensitive and foolproof.

[1] The writer on request will be glad to tell where these pieces of equipment may be obtained.

Safety in Elevator Operation

Elevator service has become so commonplace and has come into being with so little acclaim that few people really appreciate its importance. Other means of public transportation for various reasons have had their importance forced upon public attention by lack of such facilities, by political agitation or otherwise, but the old elevator has kept right on going up and down, carrying passengers and freight.

Since elevator service is free, no record is kept of the number of passengers carried, so that any figures available on this subject are only at best estimates. These estimates would indicate that the 15,000 passenger elevators in the Borough of Manhattan, New York City, carry more passengers than all the subway, elevated and surface lines of Greater New York. This emphasizes the importance of elevator service in the handling of passengers, and to this must be added the freight-elevator service, which in certain types of buildings is of equal or greater importance than the passenger service.

Another thing that is not generally appreciated is that a passenger elevator is the safest means of transportation there is. On the trunk-line railways of the country a fatal accident occurs for each 6,000,000 passengers carried. On the elevated and subway lines of New York City there is a fatal accident per year for about every 12,000,000 passengers carried, while on passenger elevators a fatal accident occurs for about every 125,000,000. These figures will vary from year to year, but the low fatal accident rate is a tribute to the safety of the elevator equipments. If an elevator is equipped with proper safety devices, a fatal accident is practically impossible while the passengers are in the car or at the landings, unless the safety devices are made inoperative. This is the experience in the states and cities where the installation of such safety devices is made mandatory by state or municipal laws.

EDITORIALS

F. R. LOW, EDITOR

X-Ray Tests of Welds

IT HAS frequently been suggested that the X-ray, which has been such a boon to the surgeon, should be of value in testing the soundness of autogenous welds. Other methods of testing involve destruction or at least subjecting the weld to some stress. To learn more of the possibilities and limitations of the X-ray for this purpose, *Power* last year secured the co-operation of two important research laboratories, which volunteered to make the necessary tests and interpretations. A twelve-inch weld specially made at the Union Carbide and Carbon Research Laboratories was X-rayed at the Watertown Arsenal and then returned to the first-mentioned laboratory, where it was cut up for physical tests. The methods used in this interesting investigation and the results obtained, are classified in the leading article of this issue.

A comparison of the X-ray indications with results of tensile tests and microscopic examination, show that the X-ray has a definite but limited value. Certain types of defects, particularly voids, are clearly shown. On the other hand, poor fusion at the junction of weld metal and base metal does not seem to register on the X-ray photographs. This should warn one against jumping at the conclusion that a weld must be sound simply because no defect appears on the plate. Further study is needed not only to increase the effectiveness of the X-ray, but also to render the apparatus more suitable for shop use.

Cheap Power an Aid Toward High Wages

"IT USED to be thought," said P. W. Litchfield at the Annual Meeting of the United States Chamber of Commerce, "that the first thing to cut when profits began to shrink was wages. It is now recognized that this condition should be met by increased efficiency, elimination of waste, the cutting down of overheads in production and distribution, and an attempt to maintain wages by these entering into increased and more efficient production; because a general cutting down of wages curtails the demand for the finished products of industry, the demand for which is the very life-blood of prosperity."

The logic of Mr. Litchfield's remarks is incontrovertible and is being indorsed by many far-sighted executives. In the further elimination of waste and increased efficiency of production, power becomes a two-fold factor—first as a means of securing greater production per worker, and secondly, as a component in the cost of the manufactured product. Greater electrification of industry, whatever the source of power supply, on the one hand, and modernized power generating equipment, together with better operating practice on the other hand, are essential requirements to this end.

Appreciative of this situation, many industrial plant managements are now taking a keen interest in their power problems. Higher steam pressure, improved firing methods, bleeder turbines and more intelligent application of process steam are some of the measures being adopted. In spite of the marked activity in this respect, indications are that the revamping program has only begun.

Integrating Temperature and Pressure

INTEGRATING mechanisms are increasingly used in connection with the various types of meters measuring the flow of water, steam, compressed air, etc. In most such cases the totalized reading is fully as important as the record of flow variations, and in some cases more important. Elimination of the labor required to planimeter charts may warrant a substantial increase in the cost of the instruments.

But integrating attachments need not be limited to meters measuring flow. They have a place wherever averages are desired, as is often the case with such measurements as pressure and temperature. In some large stations important temperature and pressure charts are planimetered daily as a necessary step in figuring averages for the daily log sheet. This labor can be avoided by an attachment on the instrument totalizing "degree-hours" or "pound per sq.in.-hours."

By noting the totals at regular intervals—say once a day—and then dividing the difference by the elapsed time, the average pressure or temperature for the given period is easily obtainable. Such instruments are already on the market and give promise of much wider use as engineers become acquainted with their labor-saving possibilities.

Who Did It?

WHERE did these things come from? Streets swarming like beehives with automobiles! Airplanes in the sky! Messages flying everywhere over wires! Entertainment and information broadcast through the ether! Railroads—underground, elevated and transcontinental! Engines, turbines, boilers, steam shovels! Music imprisoned on perforated strips of paper and in grooves on molded disks! Synthetic dyes of a thousand hues! Photography extending man's vision to the ends of the earth! Surgery, medicine and psychology performing wonders with the damaged human machine! Great liners spanning the Atlantic in five days! Who made these wonders without which life, as we know it today, could not exist? And who will perform the still greater wonders yet to come?

Seeking an answer, one thinks first of Ford, Edison, Stevenson, Fulton, Osler, Watt and Marconi—of the great engineers, surgeons, builders, organizers and business men. Let them have every praise. Their works

are almost beyond belief. But let us not forget the workers in pure science—men like Newton, Faraday, Kelvin and Milliken, who have laid or are laying the foundation stones of physical science; like Priestly, the discoverer of oxygen; Gibbs, who made thermodynamics a tool of the chemist; Napier, who discovered logarithms; Gallileo, who brought order out of a maze of planetary motions; or Pasteur, whose test tubes sealed with cotton held the key to the conquest of infectious diseases. Such men as these workers in pure science have laid the foundations of our civilization. To them must go the greater glory.

But the same history that proves us the everlasting debtors of these scientists, warns of impending danger. Great industries understanding at last that research is golden, are organizing industrial laboratories and manning them with the best talent obtainable. Hardly a large corporation in this country is without its laboratory for advancing the applications of science in its own field. This is a wonderful thing as far as it goes, but in the very act of developing the streams of knowledge, it threatens to dry up the watersheds. Scientists are but human; many are leaving their work in pure science for the better pay and more ample facilities of the commercial laboratories.

A committee of public-spirited men, headed by Herbert Hoover, has sized up the situation and started to raise a fund of $20,000,000 to support pure research. If history is worth the paper it is written on as a guide to the future, this money will be repaid a thousand times in the results of new discoveries. By thus liquidating a small fraction of its accumulated debt to pure science, industry will reap other golden harvests in the future.

Three millions are already promised, and the whole sum asked for will soon be raised if American business has learned to know a good thing when it sees it.

Improvement of Old Steam Stations

MANY of the older central electric generating stations throughout the country were built before it was common practice to bleed the main units to heat the boiler feed water. When economizers are not installed, the feed water is heated in such plants only to about 212 degrees Fahrenheit by the exhaust steam from auxiliaries. These stations are still in operation and are needed to carry the loads of their respective systems. The engineers responsible for such plants would like to secure higher economy and greater output from these old stations, and many plans have been suggested to secure these ends. The recent description in *Power* of the new addition to the Narragansett Electric Lighting Company's station at Providence suggests a scheme that might be applied to many of these older stations.

The Narragansett plant contained older turbines of 125,000 kw. total capacity but without bleeder connections. The feed water was heated to about 212 degrees Fahrenheit by exhaust steam from auxiliaries. The new 35,000-kilowatt unit is designed for bleeding at three points and, furthermore, is so arranged that it heats not only its own equivalent feed water, but also all the other feed water of the station in its third or high-pressure bleeder heater. As much as sixty per cent of the total steam entering the turbine is withdrawn at the three bleeder points. The increase in the feed-water temperature of the older section of the plant increases the steaming capacity of the boilers to which it is supplied. Furthermore, this regenerative use of steam to heat feed water will tend to increase the overall efficiency of the station and thus reduce the fuel cost per kilowatt-hour output.

The same scheme can be applied to many other old stations where an additional turbine is about to be added. This turbine can be designed to increase the feed-water temperature of the whole station, thereby securing the desired increase in steaming capacity and improved economy. In other cases it may not be possible to add a new condensing turbine. It may then pay to consider a turbine designed solely for feed-water heating with one or two stages of bleeding at high pressures to heat the feed to the desired higher feed temperature. The governor could be adjusted to provide only the necessary steam for feed heating. The power output would not be large. This unit would probably be relatively small and could be easily accommodated in some part of the station. Under many load conditions the savings effected by such a turbine would warrant the investment.

This suggestion may encourage engineers to study over the heat-balance possibilities of their old stations.

Is the Pulverized Coal Engine in the Offing

MENTION was made some time ago editorially of the experiments being carried on in this country with an internal-combustion engine using pulverized coal as fuel. This type of engine has apparently gone beyond the experimental stage, for one such engine has been in operation in Germany for about four years. While so far the running of this unit has been confined to the manufacturer's erecting floor, the reported results are so favorable that it is not unreasonable to expect the design ultimately to be adopted commercially.

The objection frequently raised by engineers experienced in oil-engine work, that the high ash content of pulverized coal would damage the liners, has apparently less basis than at first appears. If the ash after combustion is but slightly abrasive, the wear on the liner should not be excessive, and inasmuch as the ash would not have the cohesiveness characteristic of the residuals of petroleum burning, it is claimed that the proportion adhering to the walls would be slight. Even though the wear be high, the cost of the fuel is so low, amounting with five dollar coal to little more than one mill per horsepower-hour, the proponents of the coal engine point out, that frequent liner replacement would not necessarily be uneconomical.

Of equal importance is the question of fuel preparation. Even though, as it is claimed, the coal need be no finer than required in a boiler furnace burning pulverized coal, it is apparent that the engine's economy of combustion must bear some relation to the fineness of pulverization. In the existing engine the grinder or pulverizer is located on the cylinder top. For some units this may be satisfactory, but large installations would demand a separate pulverizing equipment.

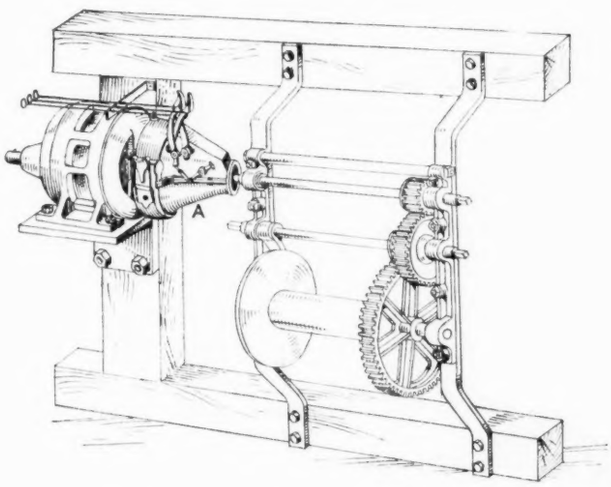
Viewing the development from a commercial standpoint, it would seem that its application is to be found in the large installation when the total yearly fuel bill is so high as to warrant the expenditure of considerable money on maintenance and renewals.

Practical Ideas From Practical Men

Another Use for a Ford

Some time ago need arose for a means of reducing speed and provision for reverse motion in connection with a winch. Inquiry developed that speed-reducing gear sets were rather expensive, and I set to work to evolve something practical and inexpensive and out of material easily obtained.

A double-reduction hand crab with a single drum, which I found here, supplied the winch mechanism. Electric motor drive was imperative, and I found it



Ford transmission used on hand crab

would be necessary to reduce the speed of a 900-r.p.m. alternating-current motor to 18 r.p.m. at the crab drum. A visit to an auto-wrecking shop supplied me with a Ford planetary transmission complete and in good condition, for $4. I remodeled the crankcase slightly, connected the flywheel direct to the 5-hp. motor and connected the other end of the Ford transmission to my crab. When the motor is started, the crab stands idle. By pushing on the reverse pedal a 4 to 1 reduction of speed is obtained at the first crab reduction, and hence, by the double reduction on the crab we get 18 r.p.m. at the drum.

By releasing the reverse pedal and pressing the low-speed pedal, the crab shaft is run in opposite direction at a higher speed. The advantage in all this lies in the fact that an efficient speed reduction is combined with a clutch and reversing mechanism at a low cost. The most satisfactory speed reducer one could purchase was priced $125. The clutch, which was essential, would have come extra, and the reversing feature likewise. So far this mechanism has cost about $38. This application of a portion of the much maligned flivver might prove useful to others, for there are numerous possible applications about a plant.

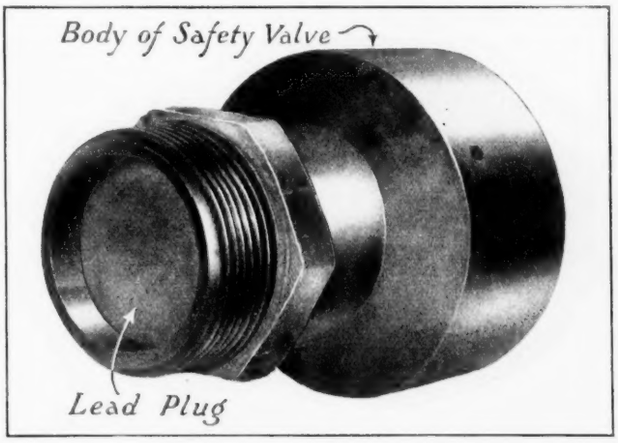
Oskaloosa, Mo. FRANK T. WARD.

Plugged Safety Valve Causes Explosion

A few weeks ago a small portable sawmill boiler, in the northern part of Louisiana, exploded, causing the death of one man, the serious injury of another and totally ruining a good boiler. Investigation developed the following:

Two days previous to the accident, the safety valve, which was a 1½-in. spring-loaded pop valve of the non-adjustable type, and set to blow at 125 lb., started blowing off frequently while the steam gage showed only 75 lb. That night the foreman of the mill, took the pop valve off and, turning it upside down, poured it full of lead. When the boiler was again put in service, it was only a matter of a few hours until it exploded, with results as before stated. An examination of the steam gage disclosed the fact that the cock underneath was completely choked up with rust. Of course the defective gage was the cause of the safety valve blowing off so much, until it was plugged.

The foreman's only excuse for rendering the safety valve inoperative was that he thought the spring was



Body of safety valve plugged with lead

weak; he also stated that he had been operating steam boilers for over twenty years.

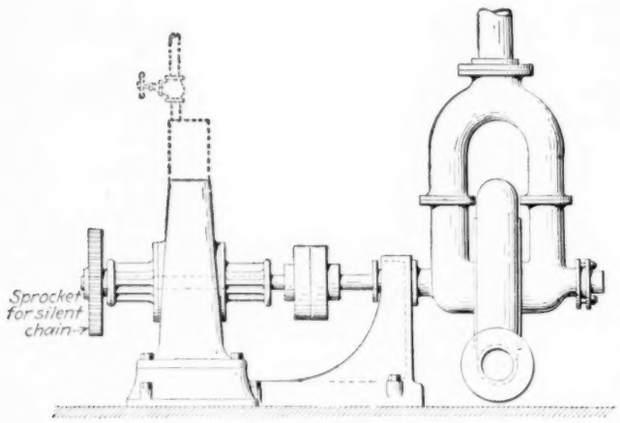
I am keeping the safety valve with the lead in it as a souvenir of a type of ignorance which, though seemingly unbelievable, is nevertheless found occasionally among men in charge of steam plants in localities where anyone who can manage to get hold of a steam boiler can use it in any way he sees fit. This plant had never been inspected by a competent or authorized inspector, and in my opinion this accident brings out the fact that boiler inspection has rendered in the past, and is still rendering, the public a great service in educating steam users how to operate their boilers and the necessity of leaving safety devices alone.

New Orleans, La. CHARLES P. WHITTY.

Rotary Heating Pump Changed from Engine to Motor Drive

When the crankshaft broke on an old vertical engine that was directly coupled to a rotary pump, we decided to change over to motor drive, as we found that it would cost less to operate this pump by electric current than by steam.

We felt that the engine frame with its bearings would serve our purpose without any other changes



Pump arranged for motor drive

except replacing the broken crankshaft with a straight one. The new shaft was fitted into the coupling and a suitable chain sprocket was mounted on the opposite end. The steam cylinder, with its connection, was removed. The motor (5 hp.) was secured to the floor and the chain put on the sprockets. This change was made three years ago, and the drive has given satisfaction. J. LIMBRUNNER.

South River, N. J.

How Can the Engineer "Sell" Himself?

In order to "sell" himself the engineer must understand salesmanship and advertising, because his employer usually is not an engineer and does not wish to know anything about the plant except cost and reducing it. He is not interested particularly in how this or that result is accomplished or who does it. The engineer cannot expect to sell himself or his ideas with a technical argument and generalities as to possible savings. The boss wants facts in dollars and cents, not strength of materials or the flue-gas analysis.

Could the boss sell you a bookkeeping system by talking about the ink and paper used? Probably not, and neither can the engineer get his ideas considered by talking about CO_2 and the cost per foot-ton in moving coal, but the statement that $20,000 can be saved the first year by installing a coal storage and reclaiming system will get a hearing. If the facts are presented in dollars instead of the size of the bucket and the cable used, the idea will be tried out. Rest assured that there is no superintendent who will not consider an opportunity to save money, but place the idea before him in his language.

Selling is the art of so clearly presenting a proposition from the prospect's needs to the solution that he thinks he has found the solution himself, that the idea is his own, and he buys.

The average engineer does not seem able to analyze cost from the business end of the stick. His idea is that his interests (No. 4 boiler bagged a tube) are the superintendent's, which is not the case. The superintendent wants to know what it will cost to prevent this trouble and whether the investment will pay dividends, whether it is cheaper to put in new tubes or rebuild the furnace so they will last longer.

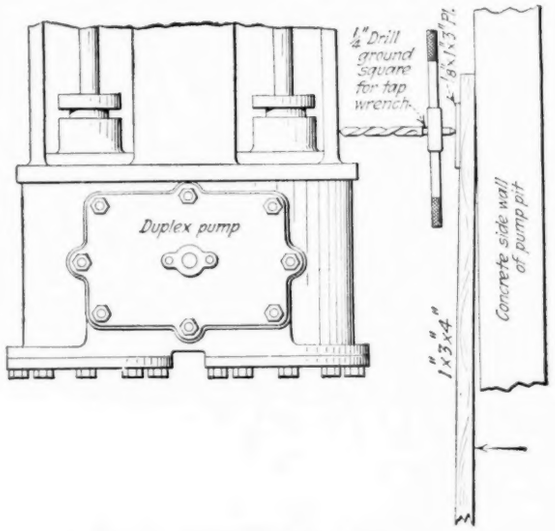
A new engine never was obtained by the writer by telling his superior that the old one was out of date, but he was given three engines by proving that the investment would pay 30 per cent interest. When the chief goes to the office with a proposal, he will have to leave his problems, worries and overalls in the plant and turn salesman. L. A. COWLES.

Vermilion, S. D.

How the Holes Were Drilled in a Limited Space

Some time ago it became necessary to drill a number of holes in the frame of a duplex pump in our plant. As there was only a 7-in. clearance between the pump and side wall of the pump pit, a ratchet could not be used, as the shortest over-all length of a drill and ratchet was about ten inches. We first thought of taking the pump out of the pit, but as that would take at least a day, we decided upon the plan shown in the illustration.

We ground the shank of a drill square and put it through a small tap wrench, leaving about ½ in. of the drill shank protruding. With some blocking and a short



Drill was turned with the tap wrench in place of ratchet

piece of board for a lever and a piece of iron plate to put between the end of the drill and the lever, we started the drilling. One turned the drill with the tap wrench while the other gave the necessary pressure on the lever. In 1½ hours we had the drilling finished. This method of doing the job saved at least six hours over taking the pump out of the pit. F. W. SPEAR.

McKittrick, Calif.

Comments from Readers

Something More Needed Than Supposed Precedents

The editorial in the April 20 issue of *Power*, entitled "Something More Needed Than Supposed Precedents," strikes a note that should receive careful consideration by every engineer planning and maintaining power installations. Adherence to established standards is advisable where the ground is uncertain and experience lacking, but the real progress is made by the pioneer who breaks away from the beaten track and follows his own ideas. Adequate experience and carefully worked plans are necessary to avoid unpleasant consequences, but where a careful investigation indicates a divergence from the accepted standards to be advisable there should be no hesitancy.

I have felt for a long time that the average conception of the electrical engineer in the selection of motors and starting equipment has been too narrow. The entire problem is presented in a different light if we assume a broader viewpoint. The electrical equipment of a plant should be considered as a means of controlling and applying power to the parts of the machine that accomplish the actual work. The primary basis of the selection of the equipment should be on the basis of its application to the industrial process, and the electrical characteristics should be a secondary consideration. This may sound like heresy, but the writer would not allow a lowering of electrical standards.

The primary points of study in the application should be made and decided before the electrical features are considered. The following are usually the most important:

The amounts of power to be applied on the various parts of the machine.

The interrelation of the various parts. Should they be mechanically or electrically interconnected?

The application of motors to the driven parts and the advisable size, speed, characteristics desirable, and method of mounting.

The reduction of intermediate mechanical parts to a minimum.

The selection of the most convenient type and location of starting and control equipment for the operation of the machine.

The reliability in operation of the various component parts.

An installation of these characteristics, compared on the basis of electrical installation costs only, would probably be more expensive than the customary type of equipment. On the basis of the installed cost of the entire machine compensated for the saving in operating costs, the benefit becomes noticeable. In many cases the increased expenditure for electrical equipment will result in a lower installed cost of the complete machine.

In a recent installation all motors below 50 hp. were specified as 440-volt three-phase 60-cycle and those above 50 hp. as 2,300-volt. All 440-volt motors, including a number of 30 hp. and below, were started by means of the "across the line type" of contactor with time-limit overload relays. A heavy-duty type of three-pole contactor rated at 75 amperes and 440 volts with magnetic blowout was selected, the only difference in rating being in the relay coils. This type of starter allowed the control stations to be grouped where convenient to the operator. The cost was considerably below the cost of the hand auto-starter.

The motor service was varied and included fans, centrifugal pumps, rotary coolers, screw conveyors, bucket elevators and the many uses for which the small motor is required in a cement plant. No belting was used, all the motors being direct connected to the individual machines through flexible couplings and some using an inclosed type of speed reducers. No serious difficulties have been encountered from mechanical shock to the parts in starting. The electrical feeders are quite large and the peaks in starting are not noticeable. It is too early as yet to state that the life of the winding has not been affected, but no noticeable effects have shown and the motor manufacturers have stated that these motors should stand this service without damage.

This equipment has been in 24-hour service for approximately one year and the results are interesting in the small amount of maintenance repairs required. For this type of service the hand auto-starter has a very considerable amount of finger replacement and other repairs. On the grounds of continuity of service the installation has been justifiable. The convenience of operation has been of material assistance in the reduction of operating labor.

For the larger motors a starting bus is maintained at 1,440 volts by means of a central bank of auto-transformers. The starting equipment for the motors are double-throw three-pole oil-immersed contactors arranged to connect the motor to the starting bus and then to the running bus. These motors range in size from 50 to 100 hp. for the induction motors.

The synchronous motors are started in a similar manner and range in size from 100 hp. to 900 hp. The load on these motors is applied after the motor has reached full speed by means of a magnetic clutch.

As an emergency measure, for several weeks all the 2,300-volt motors were started by throwing them directly across the line. No bad effects were noted or afterward traced to this procedure.

It is my opinion that operation of this equipment has demonstrated the soundness of the points considered in breaking away from accepted standards in this installation. The operating reliability and installation cost both justify the simplification of starting equipment and the convenience in operation of the remote control is a valuable factor. The limiting factor is not the motor or the load but the ability of the power system and feeders to assimilate the peaks without undue disturbance.

T. H. Arnold,
Southwestern Portland Cement Co.
Osborn, Ohio.

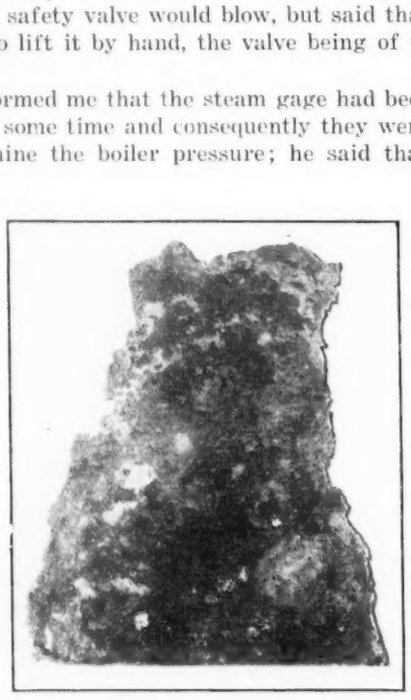
Either the Hammer or the Hydrostatic Test Would Have Revealed the Dangerous Condition of This Boiler

In view of the extended discussion that has been going on in the columns of *Power* on the relative values of the hammer and hydrostatic test for boilers, it occurred to me that the readers might be interested in the details of a small boiler explosion that occurred recently.

The boiler was a horizontal return-tubular, used for heating in a large greenhouse. The shell was 9 ft. 5 in. in length and 36 in. in diameter. The longitudinal seams were double-riveted, the rivet spacing being 4 in. The point of rupture was directly over the center of the firebox approximately 15 in. from the front tube sheet; the section of the shell dislodged was almost circular and about 10 in. in diameter. The original thickness of the plates was $\frac{1}{4}$ in., but the piece shown in the photograph, which was cut from the periphery of the rupture, is less than $\frac{1}{16}$ inch.

I had the opportunity to question one of the attendants who was within 300 ft. of the boiler when the accident happened. He said that pressure had been raised on the boiler about 10 a.m. and that he was sure that the water level in the boiler was OK when the rupture took place. He did not know the pressure at which the safety valve would blow, but said that it was possible to lift it by hand, the valve being of the lever type.

He informed me that the steam gage had been out of order for some time and consequently they were unable to determine the boiler pressure; he said that a new



Section of plate cut from boiler shell reduced to about one-quarter its original thickness

gage had been ordered and they had planned to install it the same afternoon. After the explosion the steam gage was indicating 29 lb. The water column was connected to the boiler with $\frac{3}{4}$-in. wrought-iron pipes that were so badly corroded that a slight pull broke the column from the boiler. The only means of blowing down the column was with a $\frac{1}{4}$-in. petcock, which was found to be in the open position but was completely clogged with sediment.

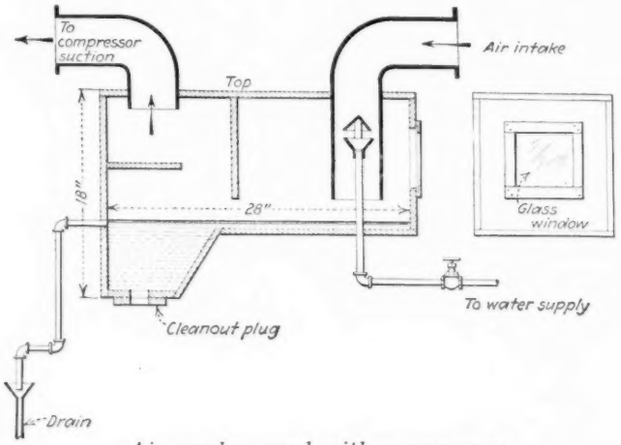
EDW. CARLSEN.

Muscatine, Iowa.

Air-Compressor Filters

In reference to the discussion in the March 30 issue of *Power* on "Filters for Air Compressors," I have tried out a number of the filters offered for the purpose of cleaning air. At our plant it is necessary to have the compressed air for agitating and emulsifying liquids as free as possible from any dirt or oil.

The most effective method was to take the air from outside the building, at a point 20 ft. from the ground



Air washer used with compressor

and to use the air-washing box shown in the illustration. This was placed inside the building and connected into the compressor suction lines 30 ft. from the machine.

No dirt of any kind can pass this box, and the machine is also very quiet in operation; the noise usually heard at the intake of air compressors was entirely eliminated.

Another surprising effect is that the compressed air delivered from the discharge lines is dry and free from moisture all the time. This device is being perfected for use on automobiles for cleaning air taken in by the carburetor.

T. F. CURRY.

Elmhurst, N. Y.

Twelve Hundred Pound Pressure Plant

The letter on "Twelve Hundred Pound Pressure Boiler Plant," by Phillips Badenhausen in the March 9 issue will appeal to most engineers, as there can be no doubt that for high-pressure boilers the drum type, where all parts are circular, must eventually hold the field. I agree with Mr. Badenhausen that it is undesirable to have numerous handhole caps as in the type of boiler adopted at Weymouth.

There is one statement, however, in the letter which is incorrect; that is, that "experience with boilers of the Yarrow and Thornycroft type shows that the vertical tube $1\frac{3}{4}$ in. and only 7 or 8 ft. long, will burn out." Far from this being true, large numbers of Yarrow boilers with tubes $1\frac{3}{4}$, $1\frac{5}{8}$ or $1\frac{1}{2}$ in. and even smaller diameter and up to 11 or 12 ft. long, have been working for long periods at nearly 900 per cent rating without showing any signs of overheating or of having reached the limit of rating due to circulation.

Had Mr. Badenhausen's statement been correct, it is unlikely that the Yarrow type of boiler would have been so widely adopted in the marine service.

W. YARROW,

Glasgow, Scotland. YARROW & CO., LTD.

What Is the Demand for Overload Capacity?

C. F. Hirshfield, in his paper, "What Is the Demand for an Overload in the United States, and What Are the Chief Reasons for Such a Demand?" presented before the International Electrotechnical Commission, which was abstracted in the April 27 issue of *Power*, brings out a number of interesting points in connection with the rating of apparatus. Progress in engineering will from time to time render rating methods obsolete, and in an international organization the liberal designs of American equipment will require some explanation. The writer recently had occasion to apply American made motors to equipment designed in Europe. In many cases the motors applied were smaller than the designers' recommendations and yet the tests in operation did not show overload on the motors. The original designs called for the 50-deg. motors, which are in common use in Europe, and allowance was made for abnormal conditions by excess capacity.

Standards of what is considered satisfactory operation vary considerably. Operating conditions and load characteristics differ radically. The manufacturers are faced with the dilemma of either furnishing a standard line of motors for practically all services or a wide line of semi-special motors to suit varying conditions. It is probable that the savings from quantity production of the former will offset the material saved in the latter. The power companies favor a closely rated motor, as many of the power rates are based on the connected horsepower. For heavy-duty service the 50-deg. motor is out of the question unless operated considerably below rating. Room temperature, altitude, and climatic conditions frequently will reduce the rating of motors materially.

During the war the manufacturers removed the 40-deg. motor from the market. This was followed by a barrage of protest in the technical press by the men in charge of operation of this equipment; many still specified 40-deg. motors and obtained them. In the end the manufacturers found the demand sufficiently insistent to warrant the return of the 40-deg. motor.

At that time I was in the Southwest. We were endeavoring to produce copper a little faster than the munition manufacturers could consume it. The room temperatures frequently were 125 deg. F. or above. We were told the safe operating temperatures for continuous operation should not exceed 90 deg. C. The altitude ranged from 4,000 to 7,000 ft. and the humidity from 15 to 40 per cent. The 40-deg. motor under these conditions would barely get by.

The advent of the 50-deg. motor was not an event to us, it was a calamity. The motors had difficulty in starting the loads and many roasted out in operation. They were usually fully loaded 24 hours a day and 7 days a week. An irate superintendent trying to get the last pound of copper appeared in case of shutdown. This was the school in which some of us received our education in the advantages of the motor having a 40-deg. rating.

There are probably many places where a light-duty motor would give satisfactory service. It may be that both the light-duty and the heavy-duty motor are justified. This, however, would add considerably to the manufacturer's difficulties and complicate his stocks. Anyone familiar with the present motor price books would favor a reduction rather than an increase in the number of sizes and speeds now available.

It will be impossible to eliminate the special motor, but it would appear the part of wisdom for the manufacturers to adopt a reasonable list of standard sizes and speeds for quantity production and market them on that basis, with all other sizes and speeds as special at corresponding prices.

The industrial plant is the large consumer of motors, and what the industrial plant wants is reliability in service. The power cost is usually a small percentage of the total manufacturing cost. High electrical efficiency at the expense of reliability may seriously unbalance the process efficiency. The result to be desired is a proper balance of all the factors that enter into the efficiency of the industrial operation. The engineers of the power companies and the manufacturers of electrical equipment are not always conversant with the details of the industrial process and are prone to consider only the electrical features. The most satisfactory results are attained when the electrical features are considered as a part of a complete survey of the entire equipment.

T. H. ARNOLD,
Southwestern Portland Cement Co.
Osborn, Ohio.

Writing Yourself to the Fore

The discussion on this subject which has been carried on by Mr. Terry and others in the columns of *Power* seems to me to be timely and of a distinctly encouraging tone. However, there is a phase of this theme which has not been touched upon and which in my opinion is the most important of all. That is, whether in writing for the technical press, it is sufficient to just write, or whether one had not better wait until there is something new to be said or some discussion worth participating in or prolonging. Without any intention to tramp on toes, there come to mind several names well known to readers of *Power*, of writers who seemingly take advantage of every chance to write or rather to advertise their name by expressing their opinions on every subject.

While there is always a chance that some new and valuable idea may come up in such discussions, is it not usually the case that such opinions represent merely what the authors have dug up or read in some other publication and now plagiarize for their own benefit? Undoubtedly, there is value to them in having their names appear in *Power*, but is it fair to the many who are earnestly trying to educate themselves and exchange ideas with others through this medium that these writers should burst into print at any occasion?

The writer has written a few short articles which were of value sufficient to be published, and while it is not felt that any new or world-beating ideas were advanced, yet in each case an effort was made to describe and give results of things that were bona-fide with the author, things that he had actually been concerned with. What makes *Power* valuable to the reader is the original ideas and practical information it contains.

What are the opinions of *Power* readers on this phase of the subject? Is the man who uses the press for self advertising playing fair to himself and his fellow engineers?

CHARLES E. COLBOURN.
Jeanette, Pa.

New and Improved Equipment

Fulton Diesel Uses a One-Piece Frame

While the en bloc design, wherein the cylinders are cast as a unit with the frame, is a feature of many automobile engines as well as other small powered units, the adoption of this design by the Fulton Iron Works for Diesel engines of over 100 horsepower per cylinder marks a new advance in oil-engine development.

The bedplate, which serves as the bottom of the crankcase, carries the crankshaft bearings in double-webbed cross-members. The en bloc casting rests upon the bedplate and extends from this plate to the top of the cylinder liners. As a result all stresses are transmitted from the cylinder head to the bedplate through a solid casting.

In effect the frame assists the bedplate in resisting bending stress occurring when the foundation is unstable, such as on dredges, in marsh ground, etc. The cylinder liners are pressed into the bloc until the upper flange rests in a recess at the top of the frame. At the bottom of each liner there is a sealed slip joint, which permits elongation of the liner under working temperatures without distortion or cramping of the casting.

The trunk-type piston is used because of its simple design, accessibility, and the ease with which it may be effectively cooled in the larger sizes without complicated piping. A special close-grained iron is used, and all pistons are carefully machined and ground on all the surfaces.

Except those in the smaller-sized engines the pistons are of two sections. The upper section contains six narrow snap rings, while the lower section acts as a long crosshead to distribute the side thrust over a large cylinder surface, reducing the rate of liner wear.

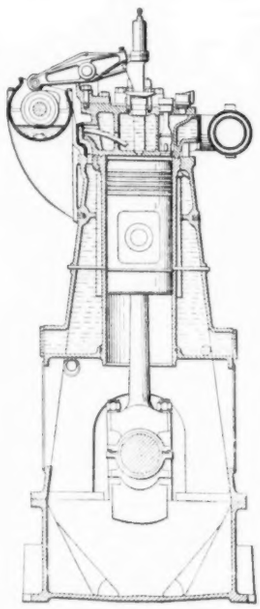


Fig. 2—Cross-section, showing cylinder cooling

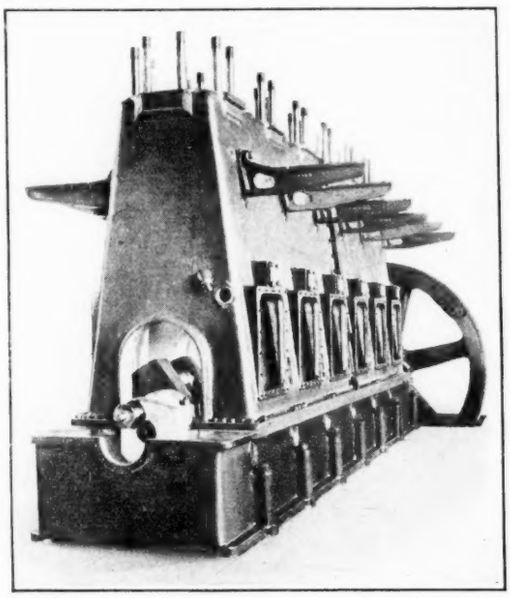


Fig. 3—En Bloc frame of a 6-cylinder Fulton Diesel

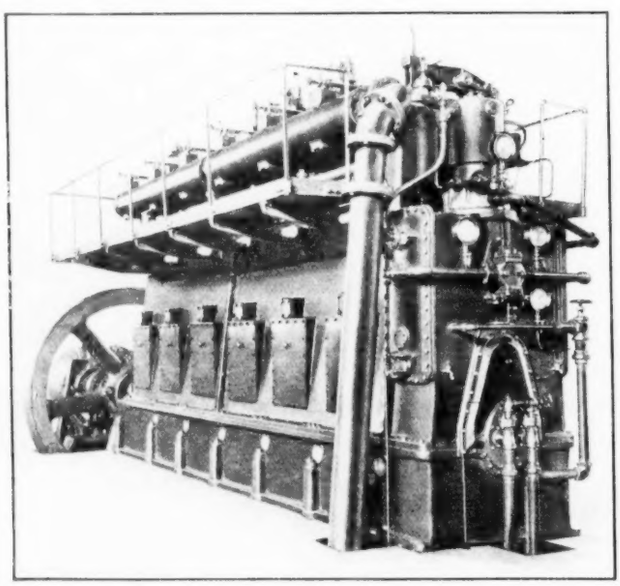


Fig. 1—Compressor end of new engine

The cylinder head is a one-piece, close-grained, gray-iron casting, with a flat bottom and top, and rests directly on top of the en bloc frame. The head design is such that a stream of cooling water is directed and plays continually upon the center of the cylinder area between the intake and exhaust valve and around the fuel valve, where the most intense heat is generated, while the engine is operated. This effective cooling of the cylinder head at this point eliminates the hot spot which is responsible for so many cylinder-head failures. The conducting pipe is shown in Fig. 2.

A free and rapid circulation of cooling water is permitted by the large water spaces in the casting, effectively cooling all areas subjected to heat.

The air compressor is the standard supplied with all Fulton engines, and is direct-connected to the crankshaft.

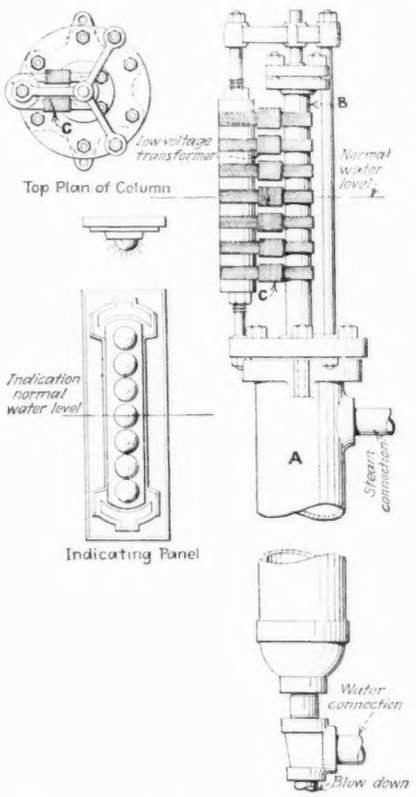
The fuel spray valve will, on the larger units, have a lift and timing adjustment device under control of the governor. The fuel is delivered to the spray valves by a pump, the length of suction strokes of whose plungers is controlled by the governor.

Ace Water-Level Indicator

A type of liquid water-level indicator used for boilers, tanks, etc., known as the "Ace," with which one or more indicating panels may be used and which may be placed adjacent to or at any convenient point some distance from the boiler, has been brought out by the W. B. Connor Co., Inc., 110 West 42d St., New York City.

The indicator consists essentially of a float chamber or column *A* with a special extension tube *B* for the armature,

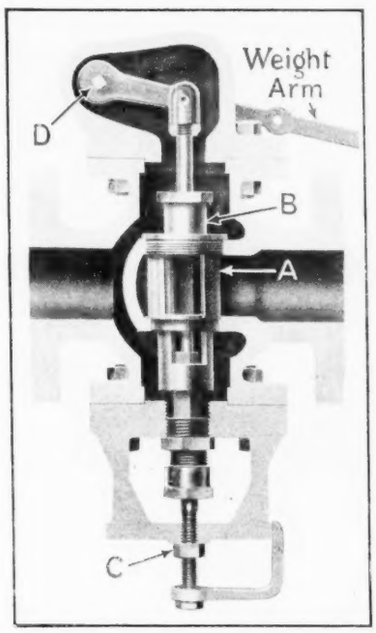
low-voltage transformers *C* and a seven-light indicating panel. The tube *B* is made of non-magnetic metal through which the magnetic flux passes across the pole of the external armature. The low-voltage transformers *C* are located outside the apparatus in order to avoid contact with the live steam. They are also not subjected to any pressure or temperature. The armature actuated by a float in the column *A* and responding to the water level, travels through the magnetic field of seven transformers, giving seven indicating points. The armature is tubular in construction, made of magnetic material and copper plated. The rod connecting the armature to the float is Monel metal. The float is kept as small as possible, namely 3½ in. in diameter, and is made of forged steel suitable for steam pressures up to 600 lb. No guides or other internal mechanisms that would tend to cause sticking and prevent operation are used. The transformers, located as they are, are not subject to excessive temperatures and the voltage carried on the primary is between 3 and 4 volts. The output of the secondary transformer when the armature is out of the field is about ¾ volt and with the armature in the field about 3 volts, operating a 3.8 volt light. The device can be used in connection with operating a series of lights of an indicator as illustrated or a graphic chart for permanent record or a high- and low-water alarm signal. The indicators are made for standard pressures of 150, 250, 400 and 600 lb., and the weight is approximately 175 lb. The water column or float chamber of the indicator can be used as an auxiliary to the standard water column as illustrated, or it can be furnished equipped with water gage to replace the existing column.



Water-level indicator employing low-voltage transformers and a series of indicating lamps

B. I. A. Control Valve With Adjustable Ports

The illustration shows the improved control valve recently developed by the Northern Equipment Co. for use with the Copes feed-water regulator. The valve is designed to allow changes in the flow area through the valve over a wide range. This adjustment permits compensation to be made in the flow area for any increase or decrease in feed-line pressure and also permits of close regulation on small flows. The changes can be made with the valve in operation.



Improved control valve

The valve differs from the control valve usually furnished, in that the seat rings are replaced with the sleeve *A* having rectangular ports, which is screwed into the body in place of the seats. The valve plunger *B*, which moves inside the sleeve *A*, also has rectangular ports of corresponding size. The changes in the flow area are made by rotating the plunger *B* in relation to the sleeve *A* so that the port area is increased or decreased.

The rotation of the valve is made by means of a lever attached to the lower spindle, which has a square recess in its top end to receive the extension on the valve plunger *B*. When the valve has been adjusted for the port area desired, the spindle is locked in place by the locknut *C*.

The valve is also equipped with a through shaft *D* fitted with double stuffing boxes. This feature tends to eliminate any unbalanced thrust on the lever shaft *D* due to high pressure.

The new valve is suitable for pressure up to 1,200 pounds.

Link-Belt Improved Loader

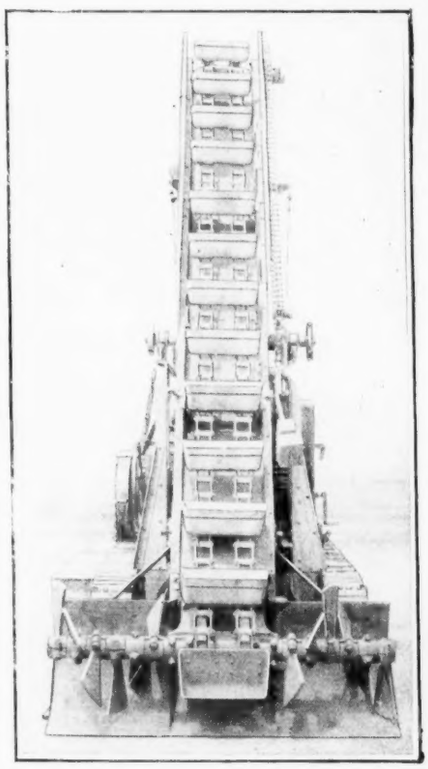
An improved crawler loader designed to handle around 140 tons per hour of coal or other crushed material, has been announced recently by the Link Belt Co., Chicago.

The loader is made up of four units —the elevator, power plant, crawler and chassis. The controls for the operating units have been so arranged that the loader can readily be handled by one man. The starting, stopping and turning are controlled by two hand levers, which automatically apply brakes when stopping.

The buckets on the elevator are carried on double strands of malleable-iron and steel chains running on manganese-steel sprockets. The driving wheel on the elevator head shaft is provided with a safety breaking pin. The feeder for the elevator consists of manganese steel paddles bolted to a hexagonal steel shaft. The chassis on which the different units are carried is made of heavy angles, plates and channels riveted together.

The power plant of the loader is a 30-hp. gasoline unit running at 1,200 r.p.m. equipped with a governor. Where desired, an electric motor can be furnished in place of the gasoline engine. The drive from the engine or motor to the different units, through the operating gear, is by means of roller chains running on steel sprockets. The treads of the crawler are made of special heat-treated steel 11 in. wide, and the crawlers are so arranged that the loader can turn left or right when traveling in either direction.

All drives are protected by sheet-steel guards, and special attention has been given to the lubrication.



Improved loader with feeder

A new slant on things observed in and out of the power plant

What Happens and Why?

Flue Gas Volume Dwarfs the Coal Pile

"OUT of sight out of mind" applies in the power plant as well as anywhere else. When one sees coal ceaselessly streaming from barges to the bunkers of a great power station or observes acres of storage space piled deep with this black food of power, he is likely to forget that fuel is an insignificant fraction of the total quantity of material handled in power generation.

For each ton handled by the coal-conveying equipment, the steam mains must carry about ten tons of steam. Even this is as nothing compared with the weight of water forced through the condensers by the circulating pumps. From four hundred to eight hundred tons of circulating water must be handled for each ton of coal burned.

On a weight basis the circulating water generally represents more than 95 per cent of all the material handled in the power plant, but on a volume basis it is a bad third. First place is taken by the steam passing from the condenser to the turbine. Allowing ten tons of steam for each ton of coal burned, and assuming a vacuum of 29 in. of mercury, the total volume of steam at the turbine exhaust per ton of coal burned would be 13,000,000 cu.ft. This is figured on the assumption that all the steam produced by the boiler passes to the condensers and that all of it is in the vapor condition. Neither of these assumptions is strictly true. Some steam goes to auxiliaries and some is bled from the turbine. Moreover, the exhaust steam is quite wet. Taking account of all these factors, the volume of the exhaust might, in a typical case, be around ten million cubic feet per ton of coal burned. This is an enormous quantity. It would fill a standpipe 113 ft. in diameter and 1,000 ft. high.

Second place in volume handled is taken by the flue gas. While the volume of flue gas produced in the burning of one ton of coal is far less than that of the steam exhausted to the condensers, it is surprisingly large in comparison with the volume of the coal.

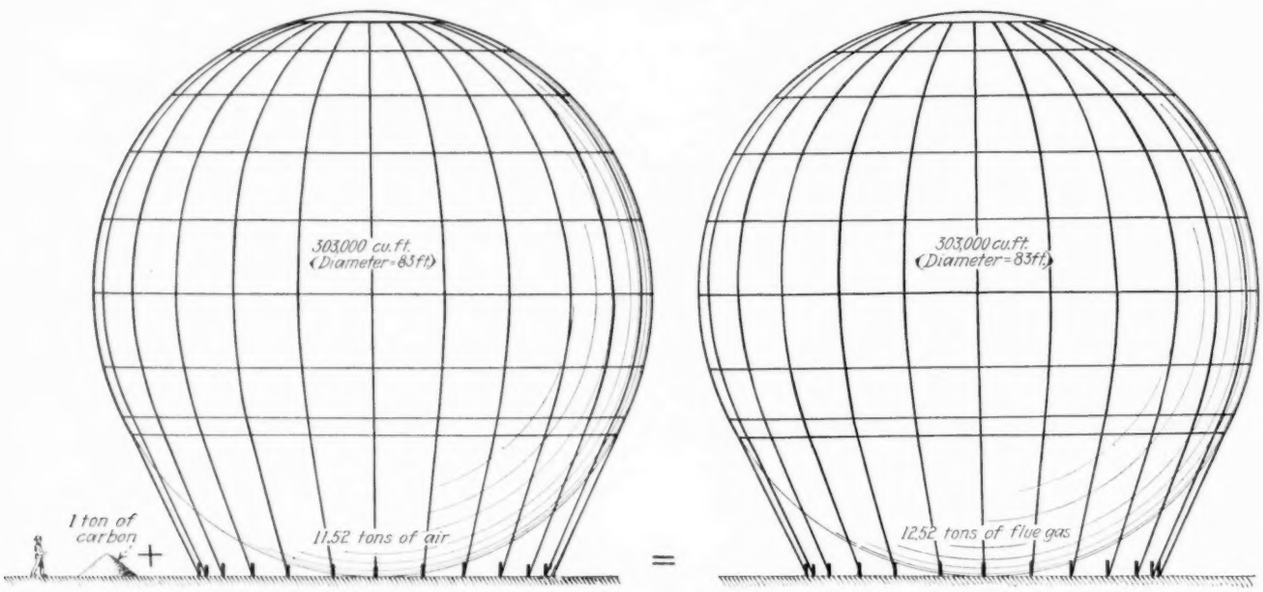
Coal is mostly carbon. Assume at the start that it consists entirely of carbon. The theoretical air required to burn one pound of carbon is 11.52 lb. Obviously, then, it must require 11.52 tons of air for the theoretical combustion of a ton of carbon. At 60 deg. F. and atmospheric pressure this amounts to 303,000 cu.ft., enough to fill a balloon 83 ft. in diameter. The accompanying figure shows a balloon with this much air, drawn to scale alongside the one-ton heap of carbon, the size of which has been figured on the basis that each cubic foot weighs 50 pounds.

It is evident that one ton of carbon burned with 11.52 tons of air must produce 12.52 tons of flue gas, since all the carbon goes into the gas. The relative weights and volumes are indicated on the sketch. Figured at the same temperature and pressure as before, the flue gas will occupy 303,000 cu.ft., which, it will be noted, is the same as the volume of the air used. This is reasonable because CO_2 has the same volume as the oxygen from which it is produced.

Several factors tend to make the quantity of air used to burn a ton of coal differ from that shown for carbon. As far as the theoretical requirements are concerned, the presence of ash tends to cut down the air required, while hydrogen tends to increase it. The theoretical air requirements of coal can be approximated very closely by allowing 1,300 heat units for each pound of air required. Thus a 13,000-B.t.u. coal would have a theoretical requirement of ten pounds of air per pound of coal.

Actually, excess air must be provided also, so that the average first-class plant probably uses about 400,000 cu.ft. of air to burn a ton of coal. This would produce approximately 400,000 cu.ft. of flue gas if measured at room temperature. But the flue gas leaves the stack at a temperature ranging usually from 500 to 600 deg., which would practically double its volume. So the final volume of combustion products of one ton of coal is at least 800,000 cu.ft., enough to fill a balloon 115 ft. in diameter.

Each time a ton of coal is burned this enormous volume of heated gas is thrown to waste. Some plants, owing to carelessness in operation of fires and maintenance of furnaces, discharge from a million to a million and a half cubic feet of flue gas per ton of average good coal. When in addition to this, leaky baffles and accumulations of scale and soot run the gas temperature well above normal, it is clear that enormous sums of money may be wasted in the flue gas. The average plant produces at least five tons more flue gas than necessary from each ton of coal.



This shows to scale the minimum amount of air and flue gas (measured at 60 deg. F.) for a ton of carbon

Reliability of Hydraulic Turbines*

Results of an Investigation Made of the Time That 56 Hydraulic Turbines Were out of Service Compared with the Outage Time for 87 Steam Turbines

IN OCTOBER, 1924, the Hydraulic Power Committee, National Electric Light Association, at the suggestion of the Eastern Division (Pennsylvania Electric Association) Committee, decided to undertake an investigation of the service records of hydro-electric units similar to the study of steam-electric units published by the Turbine Subcommittee of the Prime Movers Committee in a serial report dated June, 1924. The subject was assigned to the Eastern Division Committee, and a questionnaire covering 1924 operation was prepared and distributed. It was decided to confine the study to units rated at 2,500 hp. or more at a head of 50 ft. or more, or utilizing at least 500 cu.ft.-sec. at heads less than 50 ft. No limit was set as to the age of units to be included.

On account of the short time between the end of the calendar year and the date for submitting copy for convention reports, it was possible last year to submit only a progress report covering the 1924 record of twenty-one units. 1924 data have now been received for 56 units and a final report for that year is submitted herewith.

Terminology Used

In order to understand the results it is necessary first to understand the terminology used, which for the most part is based on the practice followed by the Prime Movers Committee:

Service time is time the unit actually operated on the bus.

Idle time is time the unit was not on the bus for any reason. It includes both "outage" and "reserve" time.

Outage time is time the unit was out of service or not available for service on account of hydraulic, mechanical or electrical trouble or maintenance, cleaning and inspection. The committee considered this to be much the most important information.

Note that outage time does not include idleness caused solely by shortage of water, such idleness being classed as "reserve" time. Indirectly, however, outage time is undoubtedly often increased by shortage of water. So far as possible all repair work on hydro units is done during periods of deficient flow. At such times there may be no reason for pushing the work. A job may be allowed to drag along with the knowledge that the unit is not needed at the time, and that if information is received of expected improvement in flow the job can be quickly rushed through and the unit returned to service.

Reserve time is time the unit was idle but available for immediate starting. Such idleness may be due to lack of either load or water.

Demand time is time during which the unit should have been operated for best efficiency or station load needs, whether or not it actually was in service. This classification was included in order to arrive at the "Service Demand Availability Factor" for comparison with steam units. In the case of a modern unit in a base-load station it is easy to say whether or not a unit is in "demand," but in other cases, such a "run-of-river" plant developed to several times the minimum stream flow and operating in parallel with steam stations, it is almost impossible to say under some circumstances whether or not a unit was in demand.

What Capacity Factor Is

Capacity factor is the average output during the entire year or record period, divided by rated capacity. This factor has relatively little to do with reliability. Rather it is an indication of the type of service demanded of the unit or the station, the condition of the water supply, etc. A unit in a uniform flow or base-load plant would naturally have a high capacity factor, whereas a unit with perfect reliability in an over-developed run-of-river plant might have a low capacity factor.

Output factor is the average output during the time of operation or service time, divided by capacity. It is an indication of the extent to which the unit is loaded while running. If this factor is low it means that the unit operates at an average output considerably less than rated capacity.

Service demand availability factor is the "Service Time" divided by the "Demand Time." It is a measure of the availability of the unit during the time in which it was needed. The fact that in some cases it was reported as 100 per cent means that all maintenance and inspection work on the unit could be done when it was not in demand.

Table I summarizes the 1924 performance data of 56 hydraulic units, and also shows, for the sake of comparison, the 1923 data for 87 steam units taken from the Prime Movers report. The sizes of the waterwheels reported range from 3,750 to 44,000 hp., while the steam units range from 18,000 to 60,000 kilowatts.

The fact that high-tension and long-distance transmission originated and grew up with, and in fact made possible on a large scale, the generation of electrical energy by water power, has caused the two things to be identified in the minds of most persons, and hydraulic power is often thoughtlessly blamed for poor dependability as compared with steam power. The results shown in Table I corroborate the conviction of hydraulic operators that a hydraulic generating unit, with all its supplementary equipment, is much more reliable than a steam-electric unit with its supplementary equipment. Probably everyone would have admitted that the hydraulic unit, *per se*, with its relatively low speeds, large clearances, absence of extreme temperatures, and sudden temperature changes, and substantial construction, is more reliable mechanically than the steam turbo-generator. Some persons, however might have claimed that the hydraulic unit with all the plant and equipment necessary for water supply and auxiliary purposes would not show up as well as the steam unit. Hence it should be pointed out that the outage in Table I includes outage of the unit for any hydraulic, mechanical or electrical cause (other than lack of water or load) and includes outage due to trouble with intakes, canals, penstocks, gates, etc. The entire plant is included, but the statistics are compiled for individual units.

Average Outage Time

The average outage time of 56 hydraulic units is only 5.4 per cent as compared with 12.9 per cent for 87 steam units, and the hydraulic units' "service demand availability factor" is 98 per cent as compared with 92.3 per cent for the turbo-generators. This is in spite of the rather surprising fact that the hydraulic units were operated more nearly continuously than the steam units, the service time of the former being 77 per cent and of the latter 72.4 per cent. The modern tendency to over-develop run-of-river plants and also to over-develop storage projects for peak load purposes might lead one to suppose that the average service time of hydro units would be less than of steam turbines.

The "maximum possible service time" of the hydro units is 94.6 per cent and of steam 87.1 per cent. These figures are based on the assumption that the outage time would not be increased if the units were operated for the entire

*Abstract of the National Electric Light Association's Hydraulic Committee's report, presented at the 49th Convention, Atlantic City, N. J., May 17 to 21, 1926.

TABLE I—SUMMARY OF OPERATING RECORDS OF HYDRAULIC AND STEAM UNITS

	Hydraulic Units, 1924					Steam Units 1923
	Impulse Wheels	Reaction Turbines	Installed Before 1920	Installed 1920 or Later	All Hydraulic Units	
1. No. of units included	8	48	21	18	56	87
2. Average turbine rating, hp.	10,080	18,070	12,160	19,170	16,930	35,400
3. Service time, per cent	51.39	81.25	75.34	73.02	76.98	72.4
4. Idle time, per cent	48.61	18.75	24.66	26.98	23.02	27.6
5. Outage time, per cent	3.55	5.73	4.66	7.87	5.40	12.9
6. Outage time when in demand, per cent	.41	1.87	3.15	1.28	1.67	8.0
7. Outage time when not in demand, per cent	3.14	3.86	1.51	6.59	3.73	4.9
8. Reserve time (4—5), per cent	45.06	13.02	20.00	19.11	17.62	14.7
9. Demand time (3+6), per cent	51.80	83.12	78.49	74.30	78.65	85.4
10. Maximum possible service time (3+8) not (100 per cent)	96.45	94.27	95.34	92.13	94.60	87.1
11. Capacity factor, per cent	16.5	51.5	51.3	40.1	48.1	33.9
12. Output factor, per cent	32.2	63.3	68.1	54.9	62.4	47.3
13. Service demand availability factor, per cent	99.59	97.75	96.77	97.86	98.02	92.3

reserve time, which, of course, is not strictly correct.

The hydraulic units seem to run more lightly loaded than the steam units, the output factors being 62.4 per cent and 71.3 per cent respectively. This fact is partly offset by the greater service time of the hydraulic units, and the capacity factor of the hydraulic units is 48.1 per cent as compared with 51.6 per cent for steam units. In both cases the annual output is not very different from one-half of the continuous use of the rated capacity.

TABLE II—ANALYSIS OF CAUSES OF OUTAGE IN PER CENT OF TOTAL OUTAGE TIME

	Impulse Wheels	Reaction Turbines	All Hydraulic Units
Number of units included	8	44	52
General Hydraulic Causes:			
Ice or trash	3.2	2.2	2.3
Floods	....	....	....
Penstock or canal	23.3	2.0	4.2
Headgates or intake	1.2	4.0	3.7
Other general hydraulic	....	1.8	1.6
Total general hydraulic	27.7	10.0	11.8
Water Wheels and Auxiliaries:			
Runner	....	19.7	17.7
Turbine valve	....	4.3	3.9
Turbine gates	....	.7	.7
Guide bearings	3.9	4.0	4.0
Thrust bearings	....	.7	.6
Governor and governor system	.6	1.0	.9
Pressure regulators	.1	.3	.3
Draft tube	....	2.0	1.8
Lubricating system	....	2.7	2.4
Inspection	8.5	1.7	2.4
Other causes	2.4	21.5	19.5
Vibration	....	....	....
Construction	....	....	....
General overhauling	....	1.6	1.5
Total water wheel	15.5	60.2	55.7
Generators and Appurtenances:			
Vibration	....	....	....
Lubric. or oil leakage	....	3.4	3.0
Rotor or field	17.1	.4	2.1
Arm. iron or windings	23.2	13.2	14.2
Exciter and rheostats	.2	.6	.6
Ventilation system	....	....	....
Cleaning	.1	7.5	6.7
Inspection	11.3	.4	1.5
Other causes	.1	.6	.6
Brushes	....	....	....
Total generators	52.0	26.1	28.7
Electrical Causes Beyond Generator:			
Switches	....	.3	.3
Bus	3.8	1.1	1.3
Transformers	.3	1.3	1.2
Outside, transm., etc	.7	1.0	1.0
Total beyond generator	4.8	3.7	3.8
Total from all causes	100.0	100.0	100.0
Total outage in per cent of total time (from Table I)	3.55	5.73	5.40

A comparison of impulse wheels and reaction turbines is interesting but not conclusive, first because of the small number of impulse wheels included, and second because of the abnormal conditions under which the impulse wheels operated in 1924. All of the eight wheels reported are located in California, and the effect of the unprecedented drought is clearly shown in the figures for service time, capacity factor and output factor. The outage time of the impulse wheels is only about 62 per cent of that of the reaction turbines.

A comparison of units on the basis of age, as shown by the third and fourth columns of Table I, is interesting as well as surprising. In a number of reports old and new turbines were combined in one return, making it impossible to classify these units by age. This accounts for the fact that columns 3 and 4 include only 39 units. Note that the older units (installed before 1920) have greater service time, demand time, capacity factor and output factor and less outage, but more outage when in demand and a lower availability factor. Some of these differences are hard to explain, as, for example, the greater outage time of the newer units, and may be considered as possibly accidental. One explanation of the smaller service time, demand time and capacity factor of the newer units is the modern tendency to overdevelop for the sake of peak service.

It would be interesting to have a comparison of the actual number of true breakdowns of hydro and steam units, that is, a comparison of the number of times units had to be suddenly taken out of service when loaded. It is believed that such instances are more rare in hydro plants than in steam plants, though there is no supporting figures for this statement.

Table II presents an analysis of the causes of outage, expressed in per cent of the total outage time shown as Item 7 in. Table I. Reports for four units were incomplete, so that this tabulation covers only 52 units.

In the case of the average of all units and also of reaction turbines, more than half the outage is caused by the wheels and their auxiliaries, with the runner as the largest single cause. The generator division comes next, with the armature as the second largest single cause. In the case of impulse wheels, however, the generator division causes over one-half the outage and the water wheels and their auxiliaries cause only 15.5 per cent of the total outage. These figures cannot be taken as conclusive, however, for the reasons previously given.

A small part of the outage in each case is due to causes beyond the generator. As we are considering primarily the units themselves, the committee decided in future to omit outage caused by parts of the system beyond the generator.

According to the National Electric Light Association, Electric Apparatus Committee's 1926 report, since stand-by batteries were first placed in service in 1894, their use has steadily increased on central station direct-current systems. At the end of 1925 their total combined capacity in the United States, for one hour at 250 volts, was nearly 900,000 amperes. The percentage of battery (one hour rate) to the direct-current peak at the end of 1924 was; Brooklyn, 13.3 per cent; Detroit, 14.7 per cent; St. Louis, 16.0 per cent; New York Edison, 22.4 per cent; Chicago, 26 per cent and Boston 46.7 per cent.

Restrictions to Flow in Hydraulic-Plant Conduits

A section of the National Electric Light Association's Hydraulic-Power Committee's 1926 report is devoted to a discussion of the effects of restrictions to water conduits of hydraulic plants by vegetable and animal growths on the surface of the water passages. It has been found that these growths cause considerable restriction to the flow, with a resultant loss of head.

Several methods of control of vegetable growths have been used. Copper sulphate, chlorine and excess hydrate alkalinity have all been used, but treatment with copper sulphate has been the most successful, and is generally the accepted method.

The amount of copper sulphate required for each different form has been carefully worked out in experiment and by actual practice. After the organism has been identified, the amount of the dose can be obtained from tables. The amount is also influenced by such factors as temperature, organic matter, alkalinity and turbidity. The higher the temperature the greater is the dose required; the presence of organic matter requires an increased amount; if the water is alkaline, a greater dose is required. In general, the blue-green algæ require a smaller dose than the green. The amounts of copper sulphate range from 0.07 to 10 parts per million. In general, 1 part per million is sufficient. "Water Works Practice," the manual of the American Water Works Association for 1925, contains a complete table on pages 168 and 169 for the amounts of copper sulphate required.

A method of control has been suggested by which copper ions may be liberated into the water by electrolysis. As the amount of copper liberated would depend directly on the volume of current, which can be accurately controlled, the percentage of copper going into solution could be easily and automatically regulated. No comparative cost data between this proposed method and the copper sulphate method have been prepared.

All the copper sulphate applied is not consumed by the organisms, but a part of the copper is precipitated out by the calcium present in the water. For this reason it is seldom that any copper ever gets into the water in such condition as to be carried down the stream and eventually consumed by human beings. This is an important consideration from the viewpoints of both the sanitary and hydro-electric engineer, as otherwise strong public resistance to the use of copper sulphate would be encountered.

In reservoirs the method of control usually employed is that of dragging burlap sacks through the water. In conduits the copper sulphate may be introduced in solution or by continuous dry feed.

When the algæ present require sunlight for existence, a more economical method of control in conduits may be had by covering the conduit. In a comparatively short conduit this method should have advantages over the copper-sulphate method of control, whereas in a very long conduit the cost of covering may outweigh the advantages.

In one case the copper sulphate was introduced in a 9 per cent solution and measured by an orifice box near the canal.

The San Joaquin Light & Power Co. has had the carrying capacity of concrete ditches and steel flumes reduced to 80 per cent of normal capacity, due to algæ growths. They describe the algæ as a brown, slimy deposit not over ¾ in. thick, cutting down the flow more by increasing the friction coefficient than by reducing the area of the section, notwithstanding the fact that the deposit gives an unusually smooth feeling to the surfaces of the conduit. The growth forms rapidly, reaching its maximum in two weeks, and starts only after hot weather and a continuous flow of water are present. The life of the growth is two to three months under the conditions on this system. No successful attempts at control of the algæ without shutting down have been made. By turning the water out and scraping the growth loose with wooden paddles, the full capacity of the conduit has been restored.

Restriction in Flow Due to Insect Growth

In the operation of some of the power conduits of the Southern California Edison Co. it has been found that the carrying capacity is reduced by the aquatic larvæ of certain insects that attach themselves in great numbers to the walls of the conduit and restrict the flow by increasing the coefficient of roughness and to some extent by the reduction in area.

The larvæ which cause the trouble are found attached to the entire surface of the conduit in thick masses near the upper portals of the tunnels or pipes and extend downstream in some cases as far as a mile and a half. Not all conduits are affected. Silt and trash destroy the larvæ, and some streams are entirely free from the pests, apparently due to the presence of mineral matter which is deposited on the sides of the conduits and prevents the formation of the cases and nets.

The larvæ are most troublesome during the spring and early summer, as this is the season of their most rapid growth as well as the period of high water, when the full capacity of the conduit is required. The reduction of capacity persists to a certain extent throughout the year unless the conduits are cleaned in the fall.

No data are available as to the increase in the coefficient of roughness due to this cause, but the capacity of certain conduits has been increased as much as 8 per cent by cleaning the wetted surfaces.

Means of cleaning vary according to the type of conduit. In the larger tunnels the only effective plan yet discovered is to turn out the water and scrape the walls. In small circular flow lines good results have been obtained by drawing a circular brush through by means of a cable, but this method entails a large amount of hard labor as well as unnecessary outage. The plan now used by this company for the smaller conduits is to sweep the pipes by means of oak brush tied up in a rough ball and carried through the pipe by the flow of water. Results of this treatment are satisfactory.

No effective means of prevention have yet been developed. Several kinds of paint have been tried on the tunnel walls at Kern River No. 3 plant, but the results were not conclusive. Apparently, the larvæ cannot cling to the surface of smooth asphaltum, and if the surface of the new concrete linings of tunnels were given a smooth coating of asphaltum paint, it would undoubtedly give a better coefficient and to some extent prevent the growth of the troublesome pests.

Industrial-Boiler Efficiencies

By Samuel D. Fitzsimmons
Plant Engineer, Brown & Sharpe Manufacturing Co.
Providence, R. I.

At the Providence, R. I., meeting of the A.S.M.E., May 4, 1926, Mr. Fitzsimmons presented and discussed the results of the boiler test at the power plant of the Brown & Sharpe Manufacturing Co., reported in *Power* for March 16, 1926. He stated that close checking of the fuel and water consumption for the last eighteen months indicates that the test data represent average performance.

He believes the efficiency of the unit (83 per cent) may be attributed to the effectiveness of absorption surface, of grate area, of air introduction, and of radiant heat.

Effectiveness of Absorption Surface

The author believes that the width of tube section, or the tube length, or a combination of the two, rather than tube section height, is responsible for the excellent efficiencies obtained. Tubes 20 or 22 ft. long arranged in a bundle three times as wide as high would seemingly approximate the most efficient arrangement.

Close tube spacing in boilers introduces operating difficulties which partly offset the contribution to efficiency. The bonding of chilled ash to the lower tubes is increased by the sooty surface of the tubes, and the close spacing facilitates bridging-over. Frequent shutdowns are necessary for removal of this ash deposit. While close tube spacing is desirable for the upper tubes, for its contribution to efficiency, the lower tubes should be more widely spaced, to prevent ash bridging between tubes.

Effectiveness of Grate Area

Owing to the large stoker installed, the combustion rate at normal boiler rating is only about 12 lb. per square foot per hour, and the advance feed of the stoker is ¾ in. per minute at 150 per cent of normal boiler rating. The low combustion rate effects complete dissociation of the volatile matter, and the low rate of fuel advance a nearly complete burnout of combustible in the refuse. Combustion acceleration and combustion capacity should not be confused in any consideration of grate area. Combustion acceleration is determined by air volume, while capacity is determined by the maximum rate of fuel feed. Depth of stoker affects completeness of combustion rather than capacity.

In stoker practice depth of grate is required for the same reason that furnace volume is required for pulverized coal. The time element is paramount. Width of grate determines combustion capacity, and depth or length determines the amount of combustible in the refuse, assuming proper stoker feed adjustment.

Effectiveness of Air Introduction

Large grate area and low combustion rate permit a thin fuel bed, and this permits a low air pressure below the grate. The air velocity is low, and this effects thorough mixture of gas and air at the surface of the fuel bed. Velocity makes for stratification, and when air-emergence velocity is reduced, the need for high settings for stoker-fired boilers is eliminated. The author concedes superiority to the pulverized-fuel furnace for ratings in excess of 200 per cent, but for ratings below 200 per cent he maintains that stoker-furnace efficiencies commensurate with the best in pulverized-fuel furnaces are obtainable. It is not apparent that a more intimate and rapid mixture can be effected in the pulverized-coal furnace than in the solid-fuel stoker furnace.

Effectiveness of Radiated Heat

The large grate area, close tube spacing and width of the tube section contribute largely to efficient projection and absorption of radiant heat. Radiant heat striking the refractory wall is largely reflected to the tube surface, and this is probably the explanation for the good condition of the refractories after more than eighteen months of service. The bridge-wall and front baffle indicate that unabsorbed radiated heat is highly destructive to refractories. The bridge wall and the front baffle are frequently repaired.

Effectiveness of radiant heat is perhaps the one real advantage stoker practice has over pulverized-fuel practice. In the stoker furnace radiant heat is for the most part projected directly to the tube surface and fully absorbed thereby. In the pulverized- fuel furnace radiant heat is projected in all directions from the incandescent particles, and much of it strikes furnace walls and is not reflected directly to tube surfaces. The introduction of water-cooled walls in pulverized-fuel furnaces will no doubt effectively absorb the radiant heat that destroys refractory in the non-cooled wall. The suggestion is advanced that installing water-cooled walls in a pulverized-fuel furnace, or placing more tubes in the horizontal dimension of a water-tube boiler over a stoker, are much the same thing, the object being more effective absorption of radiant heat. Sufficient grate area in the case of stokers will result in the same efficient projection of radiant heat that characterizes pulverized-fuel furnaces.

The author's purpose in conjecturing as to the relative merits of pulverized-fuel furnaces and mechanical stokers has been to emphasize the inherent features advantageous to the stoker which seem to have been lost sight of in the current enthusiasm for pulverized fuel.

Recent Publications

Industrial Water Supplies — Fourth Series, Bulletin No. 29. By Prof. C. W. Foulk, Professor of Analytical Chemistry, the Ohio State University. Published by Geological Survey of Ohio, Columbus, Ohio, 1925. Cloth; 6½x9½ in.; 406 pages; 223 pages of tables. Price, $1.

This book is in two sections and meets two quite different needs. The second portion, covering over 200 pages, is devoted almost entirely to a tabulated report on the chemical composition of the surface waters of the State of Ohio. Of such analyses 538 are given, with specific data regarding the places where the samples were taken and any other factors that might affect the results. These analyses should be of great value to any industrial concern now in Ohio or contemplating locating there. It would, however, be a mistake to assume that the book is not of considerable value to engineers and others who have no direct interest in the State of Ohio, industrially speaking. The first 160 pages are devoted to a valuable discussion of the general subject of industrial water supplies, with particular reference to the needs of boiler plants.

Professor Foulk casts much light on certain matters that have been more or less a secret of the chemist. The average engineer has the idea that a water analysis is supposed to show the chemical compounds actually existing in the water. As a matter of fact, no one knows or can know in the present state of chemical knowledge exactly what compounds exist in solution. If the same sample is sent to two different chemists working on different systems, they are likely to report analyses that only remotely resemble each other, and one may be as nearly correct as the other. The point is, as clearly brought out by Professor Foulk, that the chemist really determines not the compounds in the water, but the quantities of the various elements and radicals present. He then proceeds to combine these according to some arbitrary basis, the particular basis selected depending largely upon his schooling and personal prejudices.

A careful reading of the first four chapters, covering this and related matters, will be of great educational value to most engineers. Chapter 5, on the other hand, will be passed by, except where the reader is himself a chemist and desires to know the exact procedure in making a water analysis. Most of the remaining chapters are of interest to the engineer. These have the following subjects: Interpretation of industrial water analysis; hardness and water in the household; scale, boiler compound and internal treatment; corrosion; foaming and priming; purification of water for industrial use.

It is surprising that hardly a book has been available treating the general subject of industrial waters in a practical manner. Professor Foulk's book fills this need.

Power Factor Wastes. By Charles R. Underhill. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York City, 1926. Cloth; 6x9 in., 326 pages; 117 illustrations; 48 tales. Price, $3.50.

Power factor is a problem that may be considered as arising in the distribution and application of power with the development of the induction motor. No feature in power generation, distribution and use has been given any more attention in the technical press than this thing identified by many terms, but commonly known as power factor.

Until recently the mass of data on power factor was scattered in a great many technical publications. In this new book the author has been both author and editor and has attempted to correlate the information on the subject of power factor in all its phases, in an easily comprehended form. Much of the material he has written himself, but he has also quoted freely from many sources, wherever this best suited the purpose. Therefore the book is not the product of one man's mind, but that of many authorities on the subject.

The book aims to teach those directly responsible for a large proportion of power factor waste, and who pay the bills, how much these cost as reflected in actual saving made where bad power-factor conditions have been corrected; also, to call attention to the causes and cures as provided by the experience and the opinion of a number of authorities. As would be expected, these views differ, but the object has been to present as many sides of the question as practical.

Among the subjects treated in the various chapters are: Importance of keeping motors loaded; analyses of power bills; transmission, distribution and rates; fundamental principles of power factor and its correction; correction of power factor of induction motors; synchronous machine and other equipment in power-factor correction; improving the power factor with the electric furnace; and location of power-factor correction apparatus. Much of the material has been presented in a form that can easily be grasped even by the layman. Other parts are of a more technical nature. But taking the book as a whole it contains much to engage the attention of everyone interested in the power-factor problem and should find a wide field of usefulness in the distribution and application of alternating-current power.

Textbook on Hydraulics. By George E. Russell, professor of hydraulics, Massachusetts Institute of Technology. Published by Henry Holt & Co., 19 W. 44th St., New York City, 1925. Cloth; 6x8½ in.; 311 pages; 144 illustrations. Price, $3.50.

This, the third edition of this book, like its predecessors, has for its primary purpose the providing of a brief and simple presentation of the fundamental principle of hydraulics for use in the classroom. As the title indicates the book does not treat of water-power development as such, but with the laws that govern the action of water at rest and in motion, and it is these laws that enter into all water-power problems.

Being a fundamental textbook, the treatment is naturally mathematical, but many practical applications of principles are given, and each chapter is followed by a group of practical problems for the student to work out. It is the author's contention, and in this many will join with him, that the only way in which a firm grasp on the subject can be attained is by working out many numerical problems. It is to this end that the problems have been given in the book; many of them are accompanied with the answer so that the student may check his own work.

The book has been divided into ten chapters: Introduction, hydrostatics, effects of translation and rotation upon bodies of water, fluid motion—Bernoulli's theorem, discharge from orifices, flow through mouthpieces, flow over weirs, flow through pipes, flow in open channels, and dynamic action of jets and streams. In presenting the various formulas and their derivations, attention is called to the conditions under which the experimental work was carried on, and in this way it has been endeavored to keep the student out of the pitfalls that await him in the use of empirical formulas. For rectangular weirs there are five formulas, each arrived at under different conditions, therefore, the question may well be asked, which is the best? This the author answers in his discussion on the choice of a formula.

At the end of each chapter a bibliography of literature is given on the subject treated. Although this may not be as complete as it might be, it nevertheless provides the reader with a valuable reference. In the revision the author has endeavored to make the book valuable as a reference for engineers without impairing its value as a textbook, and to this end the entire work has been rewritten. The chapter on "Flow in Pipes" has been greatly expanded, and tables of coefficients have been added. Taken as a whole, the book merits the attention of all those interested in the subject of hydraulics.

"Direct-Injection Oil Engines" is the title of a new publication just issued by the Ingersoll-Rand Co., New York. The cover, which is printed in colors, illustrates the major title by portraying the Ingersoll-Rand oil engines as applied to railway, marine, power-house, industrial and building applications. The text matter, which consists of technical data and details of their "PO" oil engines of 55, 110 and 150 b.hp. sizes, is profusely illustrated by 42 illustrations of plant layouts, installation views, diagrams and engine details. A copy of this publication is available to executives and engineers on request by addressing the Ingersoll-Rand Co., 11 Broadway, New York City, or any of its representatives in the principal cities of the United States and all foreign countries.

News in the Field of Power

N. E. L. A. on Better Service Platform—R. F. Pack and M. S. Sloan Elected

National Leaders Discuss Public Relations—Samuel Insull Urges Increased Load and Power Exchange With Industrial Plants—Technical Papers Read—Plant Equipment Displayed

THE Forty-ninth convention and exhibition of the National Electric Light Association held at Atlantic City, May 17 to 21, 1926, was an impressive gathering of men and women of the electric power industry from all parts of the country. This meeting is the annual occasion for the renewal of friendships among those who are directing the activities of this industry, which stands forth as a splendid example of commercial and technical co-operation.

In accordance with the custom of the organization, the convention was featured by sessions of the several specialized sections of the Association, some held simultaneously with the general meetings. All these sessions disposed of formal transactions as speedily as possible and devoted the major portion of their time to addresses by speakers of national prominence.

Commercial Aspect

The Million Dollar Pier, where the convention sessions were held, also housed the exhibition of manufacturers' products of interest to the industry.

Entertainment features of the week provided delightful occupation for those who were not occupied by more serious matters.

The meetings were largely concerned with the commercial aspects of the industry, scant attention being accorded the splendid technical achievements of the several committees of the Engineering Section of the Association.

Technical Contributions

One valuable technical contribution was an informal talk by Professor S. W. Parr, of the University of Illinois, who described the investigations made under his direction of the cause and prevention of embrittlement in boiler plate and rivets. This work is to be set forth more fully in a paper to be presented at the meeting of the American Society for Testing Materials to be held next month, and still more fully in Bulletin 155 of the Engineering Experiment Station of the University of Illinois. The subject is of vital concern to every boiler user, and Professor Parr's brief talk foreshadows an authoritative and illuminating treatment in the forthcoming papers.

This year's Hydraulic Power Committee's report covered a wide variety of subjects, such as reliability of hydraulic turbines, vibration in hydraulic turbines, restriction to flow in hydraulic conduits due to vegetable and animal growths, and rates of evaporation from lakes. An abstract of the subcommittee's report on reliability of hydraulic turbines appears in this issue. Abstracts of the other subcommittees' reports, including the one recently made on the pitting of hydraulic-turbine runners, will be published in a later issue.

J. E. Davidson

Aside from the regular technical and commercial sessions those in attendance were privileged to listen to addresses by a number of outstanding leaders, within and without the industry. Among these were Owen D. Young, Secretary Mellon, William Allen White, Samuel Insull and R. H. Ballard. "Public relations" formed the keynote of several of these addresses.

At the Tuesday morning session, Owen D. Young, Chairman of the Board of the General Electric Company and of the Radio Corporation of America, discussed public relations and public ownership and operation. He gave "his personal views made without consultation with others and spoken in no sense in a representative capacity." He urged continued efforts toward better understanding and more cordial feeling between utilities and the public they serve. In speaking of public ownership, Mr. Young said in part: "I have had the opportunity during the last few years to observe the operation of publicly owned enterprises in most of the principal countries of the world. By and large, their efficiency in service is markedly less than private companies. Indeed it is scarcely too much to say that the best of the publicly owned enterprises are comparable only with the worst of the privately owned concerns. In many cases no one but the government would dare to give such inadequate and inefficient service as I have seen."

Mr. Young believes that publicly owned systems tend to extend service uneconomically for political reasons. Perhaps there is justification for governmental subsidy of service extensions, but that is another question.

With respect to rural electrification, the speaker expects that "before many years the privately owned company will have discovered how to serve the farmer at a profit, and correlatively they will have taught the farmer how to use the service to his profit."

His discussion of the control of water resources was of great interest. He pointed out that where rivers "require development for several purposes, such as navigation, irrigation and flood control as well as for power, there arises a new kind of question which is wholly unrelated to the old controversy of government versus private ownership.

"The private ownership people feel that if the government has anything to do with the development of power in these composite situations, it will be merely the starting point from which the advocates of public ownership will advance their operations.

Water Control the Key

"On the other hand, the public ownership people feel that the private owned companies which seek to throw dams in these great rivers, and incidentally perforce take over the effective navigation, irrigation and flood control, are so intrenching themselves in purely public operations as not only to make all thought of public ownership impossible, but to create instruments of oppression rather than of service.

"While this debate goes on, vast rivers go unharnessed for power, waterways are undeveloped, floods drown us, and droughts devour us. May I not call for a broader view in the public interest from the representatives of both the utilities and the public? Can we not find a way by which the sovereign powers of states may be recognized in the location, construction and ownership of these tremendous structures in great rivers supplying government services as well as power?

"Perhaps the key to it is the control of water. After all, it is the water which is the agency of all. It is the water which must be stored to prevent floods. It is the water which must be drawn down to facilitate navigation and irrigation. It is the water which must be drawn down to create power. In my judgment, the sovereign power

of the state should determine which of these needs is most important in the public interest from time to time. If the government prefers to use water for navigation or irrigation rather than for power, I think it should have the right to do so without protest much less opposition from any private power company. But the water must be used.

"If power can be incidentally generated from the stored water, there can be no reason why that power should not go into and become a part of the power supply of the contiguous district within reach of economical transmission. Some plan will have to be devised by which the amount and continuity of the supply of water, at least as to minimums, can be determined in advance as the basis for payment.

"The absolute essential of an electricity supply is that it be permanent and continuous. Interruptions make it almost valueless. The practical engineering problem, in my judgment, is not difficult.

Public Corporation

"Much has been made of the question as to whether these dams should be built and owned by the government. If the dams really serve the great purposes of navigation and flood control, which are clearly governmental activities, then it seems to me public ownership of them cannot be objected to. Personally, I prefer that the construction and ownership of such an enterprise be in the hands of a public corporation, the stock of which should be government owned, with the provision that that corporation finance the enterprise with its own securities."

R. H. Ballard, vice-president and general manager of the Southern California Edison Co., drew attention to public policy and politics. Politics is concerned with electing men, while public policy deals with the education of the entire population of the nation to an appreciation of sound economic principles.

Mr. Ballard dwelt at some length on the insidiousness of socialistic schemes, often masquerading and seeking justification as the solutions for problems of a special nature. He deplored the fact that men whose general thinking could usually be depended upon to be sound should permit themselves to be seduced by specious arguments in the particular case. The speaker emphasized unqualifiedly that governmental ownership in any field is wrong, is socialistic and destroys democracy.

Mr. Ballard pleaded for active support of the work of the N.E.L.A. in its various branches and through its committee activities.

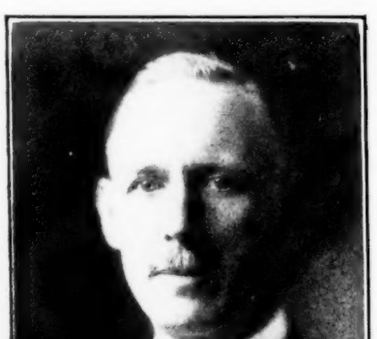
Looking Backward

Secretary Mellon, whose address was delivered from Washington and broadcast, attributed the prosperity of this country to our natural resources and to the great use of labor-saving devices, which have succeeded in keeping both wages and profits at a high level. "It was fortunate," he observed, "that the period of America's greatest expansion was coincident with the development of the steam engine, the gas engine and electric power. Both labor and capital are beginning to realize that they have a common interest in building up the great industries, which are a source of wealth for all, and that in America there is no place for class antagonisms."

Mr. Mellon attributed America's rapid growth largely to private initiative, but cautioned that our continued growth depends upon whether we pursue an intelligent and constructive or a hostile policy toward those forces which have brought about the present development.

In a remarkable review of the central-station industry, Samuel Insull made a plea for increased load to keep pace with investment and generating capacity. He also strongly advocated exchange of power between central stations and large industrial plants to promote economy in load factor and decreased reserve capacity.

He observed that output is now lagging behind investment and capacity. Investment cost per kilowatt of generating capacity declined from $425 in 1912 to $294 in 1925, when it advanced slightly. Moreover, from 1912 to 1925 the total generating capacity increased 320 per cent, while the total investment in plant and equipment, including distribution lines, increased only 194 per cent. The potential markets for electrical power are now little more than half supplied, and there is wide opportunity for increased load through greater domestic use of electricity, railway electrification, farm use and manufacturing.



R. F. Pack

Load Factor a Problem

The development of domestic load of high load-factor and good diversity is obviously a problem of pressing importance to the central station industry, and it is evident that both the power generating companies and the manufacturers of electrical appliances are attacking this problem with determination and that as experience grows the successes already achieved in some fields will be duplicated generally.

The exhibition gave perhaps half of the available space to displays of household refrigerators, washing machines, ironers, ranges and portable cooking and heating devices, and the like. There were several effective demonstrations of lighting fixtures and layouts. In the field of generation and distribution, there were full-sized and miniature models of several varieties of switching, transforming and transmission equipment. Several large exhibits were devoted to instruments for the study and control of transmission and distribution systems.

Equipment Displays

Power-plant equipment was but a small part of the whole exhibit, but the displays were significant and interesting. Three firms showed combustion-control equipment, and it was an instructive study to compare the three schemes, differing greatly in construction and methods, yet all designed to accomplish the same results.

Boilers and combustion equipment were represented largely through excellent photographs, although one display showed a model plant and an actual pulverized-coal feeder. Sections of two types of water-cooled furnace wall and of a flue-gas air preheater attracted attention.

Several valve manufacturers showed their products, with samples of pipe bends, drainers, traps and the like. The emphasis was on material for high pressure and high temperature.

A motor-driven soot blower head, recently developed, was an interesting innovation which will shortly be described more fully for *Power* readers.

Two builders of condensers and pumps had booths showing samples of smaller equipment, with drawings of their larger products.

Exhibits by construction companies were especially attractive, consisting of small-scale models of power and gas plants built recently. While the exhibition as a whole would have interested any engineer, it was addressed primarily to the electrical operator and to the commercial man who is concerned with the merchandising of appliances.

The Election

At the general session on Friday morning R. F. Pack, of the Northern States Power Co., of Minneapolis, was elected president of the Association to succeed J. E. Davidson, of the Nebraska Power Co., Omaha, Neb. M. S. Sloan, of the Brooklyn Edison Co., Inc., Brooklyn, N. Y., was elected new vice-president. Other officers were re-elected, so that the work of the organization will go forward under much the same leadership as in the past.

Electric utilities, as an industry of service, was the theme of the address by William Allen White, prominent publicist and lecturer. Stressing the fact that the industry is met with a universal demand, Mr. White pointed out that its service required the very best that could be offered. The public demand, then, should be educated and trained as far as possible by the leaders of the industry. They should set a high standard of service and supply a greater demand for it.

Fully living up to precedents set by past conventions and in many respects surpassing them, the convention closed with a registration of six thousand. A spirit of co-operation and helpfulness characterized the sessions.

Carl Hering, of Signal Achievements, Dies

With much concern and a sense of loss deeply felt in engineering circles, occurred the death on May 10 of Carl Hering, eminent consulting engineer in the fields of electricity and chemistry. A resident of Philadelphia, Dr. Hering had long lived at the Engineers' Club. On May 8 he entered a hospital to receive treatment for a slight heart affection, as it was then deemed. A sudden relapse followed an apparent improvement.

Born 66 years ago in Philadelphia of German parentage and educated in that city and in Germany, Dr. Hering had a distinguished career as a leader in the technical branch of the electrical art, which in its modern form sprang into being just as he arrived at manhood. In the electrochemical and electrometallurgical fields especially he achieved international distinction, his discovery of the "pinch" effect being his greatest acomplishment, though by no means his only one. In 1892 he served as technical editor of the *Electrical World*, and a year later he originated the "Digest of Current Electrical Literature."

Pioneer Electrical Student

Graduated from the University of Pennsylvania in 1880 in mechanical engineering, he received the degree of bachelor of science with high honors and seven years later the post-graduate degree of mechanical engineer. In later years the university conferred on him the honorary degree of doctor of science. In 1882, while teaching at the university, he began the study of electrical engineering.

Dr. Hering's work in electrochemistry began with extended researches into storage batteries prior to 1890, as a result of which he obtained numerous patents.

As early as 1883 he began the computation of conversion factors of electrical and mechanical energy, and he published a comprehensive book on this subject in 1904. A few years later he made a recalculation of all electrochemical equivalents. In 1908 he made an analysis of the interrelations of the various quantities of units entering into the calculation of light phenomena. In the same year he described an experiment purporting to demonstrate a hitherto unrecognized factor in electromagnetic induction to show that Maxwell's well-known law of induction should be modified in order to acquire the status of a universal law.

Started Electrochemical Society

Dr. Hering was one of three men who in 1901 laid organization of the Ameri-

Carl Hering

can Electrochemical Society. He was also concerned in the founding of *Electrochemical Industry*, now *Chemical and Metallurgical Engineering*, published by the McGraw-Hill Publishing Company, Inc. In 1900 he was elected president of the American Institute of Electrical Engineers. In 1904 he served as president of the Engineers' Club of Philadelphia, and in 1906 of the American Electrochemical Society. Among other technical organizations to which he belonged are the American Association for the Advancement of Science, the Franklin Institute and the Illuminating Engineering Society. He is survived by a daughter and by several brothers and sisters.

St. Lawrence Power Lease for Frontier Co-Project Plans $200,000,000 Development

Governor Smith Will Fight Commission Award Carrying Issue to Polls—Private Interests To Push Grant—Two Plans Presented Commission

ALTHOUGH no official announcement has been made, all indications point to an early grant of licenses for the development of water power on the St. Lawrence River to the Frontier Corporation of America, which is owned by the General Electric Company, the Aluminum Company of America and the Du Pont de Nemours Company. The project will involve an expenditure of more than $200,000,000.

The Frontier Corporation has at present two plans before the New York State Power Commission. One calls for an all-American development and the other for a joint development with the Province of Ontario. The former plan, it is understood, will be favored by the commission. Plans submitted by the Super Power Corporation of America for the undertaking will not be accepted, it is indicated.

It is more than likely that Governor Smith will make the matter of public development of water power a leading issue in state affairs. For months he has fought against private development and has urged the abolition of the Water Power Commission. In spite of his opposition the Legislature sustains the existence of the commission and its full functions until Jan. 1, when it will be dissolved. After that date the signature of the Governor will be required on all water power grants, but before that time the present commissioners will have carried into effect the plan of private development.

Governor Smith is in no doubt as to his campaign. When the licenses have been granted he will lead a state-wide fight to defeat the plan. On this issue, it is understood, he will unhesitatingly announce his willingness to run again for office.

The position of those who favor private development is that the cost of state development would be prohibitive, experts having said it would cost much more for the state to undertake the development than it would cost private interests. They are also convinced that the Governor's suggestion of public distribution of light and power, involving more than $100,000,000 for power lines, is both extravagant and Socialistic.

The plan, which it is understood the commission will approve, involves two developments—one at Cat Island, near where Lake Ontario empties into the St. Lawrence, and one at the foot of the Big Saulte Rapids.

Each development would have approximately thirty units of 20,000 hp. capacity each. Col. Hugh Cooper, foremost power engineer, has testified that it will be possible to bring 25 per cent of that power down as far as New York City.

Some extent of the new power plan of New York State may be grasped when it is known that the best engineering experts predict the power developed will mean the displacement of 40,000,000 tons of coal a year in the state and will almost free it from the terrors of a new coal strike, so far as industries are concerned. It will also permit the diversion to other uses of one-third of all the freight cars now used in carrying coal. It will offer a great opportunity to manufacturers for cheap power throughout the state.

Federal Power Rights Held Superior to State's

Pre-eminence of federal over New York State authority in the regulation of water-power developments in the Lower Niagara River was emphasized by the Federal Power Commission, in a letter to Charles E. Hughes, special counsel for the State, according to dispatch published in the *New York Herald Tribune*.

The letter was in reply to one from Mr. Hughes dated Dec. 14, 1925, in which he declared the state had primary authority and that the Federal Water Power Act was, in part, unconstitutional.

The correspondence centered about the proposal by the Lower Niagara River Power & Water Supply Co. to erect water-diversion works and a power plant below the falls. The commission held that approval of the chief of engineers and Secretary of War and of the International Joint Commission was necessary, since the Maid of the Mist Pool is navigable and the lower Niagara is an international stream.

Congress alone has the ultimate authority to consent to the erection of proposed structures in the river, and cannot be compelled to grant or withhold its consent, the commission said.

Canada Finds Private Power Output Costs Third Less

Canadian Government figures on the comparative cost of generating electrical power by government owned, as opposed to privately owned, power plants in Canada give striking evidence of superior economy on the side of private operation, as set forth in a recent issue of the Toronto *Financial Post*.

Comparison is made between the privately owned plants in Quebec and the Ontario Hydro-Electric Power Commission's system at Niagara Falls. The latter has been widely acclaimed by government-ownership propagandists as the model power development of the world. The Hydro has cost, per horsepower developed, 67 per cent more than the Quebec plants, with even greater percentages of waste in other particulars. The report, in part states:

"In view of the proposal of the Hydro-Electric Power Commission of Ontario to purchase power developed by the International Paper Co. of the Gatineau River in Quebec, and to bring it to the industrial districts of Ontario o sell on the same basis as that developed by the Chippawa plant on the Niagara, the point again rises as to the efficiency of private developments in Quebec under government control as compared with the public ownership ventures in this province.

"It is very difficult to get definite information on which comparative costs of power can be based, but the figures from the Census of Industry of Canada for 1924, of Central Electric Stations for Canada, indicate emphatically that a greater amount of power has been developed in Quebec on an investment nearly $100,000,000 less than that made by Ontario. In view of these findings it is likely that private operation will become universal.

More Power Units Planned For Gatineau River

Already plans have been announced for increasing the huge power development of the International Paper Co. on the Gatineau River in the province of Quebec. It had been originally intended to install four units at each of the plants at Chelsea and Farmers Rapids, but according to an announcement by President A. R. Graustein, who visited the plants recently, the company has decided to add another unit to each power house, which will increase the maximum capacity of the two plants by 58,000 hp.

Power development at Chelsea as at first planned was for 136,000 hp. This will be increased to 170,000 hp., while 120,000 hp. will be developed at Farmers Rapids, instead of 96,000 hp., as originally intended.

The company plans to develop in the neighborhood of 500,000 hp. on the Gatineau River in the near future. Of this amount, about 260,000 hp. will be sold to the Ontario Hydro Electric Power Commission. This will be developed at Paugan Falls, above Chelsea. A large block of the power will be used to operate the company's new paper mill at West Templeton, Quebec, while a considerable amount will be sold to industries in the immediate district.

Maine Tidal Power Project Authorized

Following months of consideration and planning, a preliminary permit covering a proposed development of tidal power in Passamaquoddy and Cobs Cook Bays, Washington County, Maine, has been authorized by the Federal Power Commission to Dexter P. Cooper, Inc., of Eastport, Me. The development will affect in addition the St. Croix River and lands and waters in the Province of New Brunswick.

It is proposed to contruct dams between various islands and between islands and the main land so as to divide the waters of the two bays into two pools. It is intended that water will flow from the ocean through 43 gates into the upper pool and pass to the lower pool through the power house. The lower pool will be emptied into the ocean through 30 gates when the tide is falling.

Mr. Cooper expects to obtain a mean operating head of 13 ft. between the pools and with a flow of 300,000 sec.-ft. expects to develop 2,500,000,000 kw.-hr. annually, with an installed capacity of 600,000 hp. Boston is to be the principal market for the power. Navigation is to be provided between the upper pool and the ocean by one large lock and one small lock and between the ocean and the lower pool by one small lock. Conditions have been stipulated safeguarding the interests of navigation.

With this permit Mr. Cooper now will be in a position to take up the matter of securing Canadian approval of the project.

Colleges Plan Correlation of Theory and Practice

An association recently formed by American colleges and universities giving co-operative instruction in engineering, commerce, architecture and other subjects, will hold its first annual meeting June 14 and 15 at the University of Cincinnati, where the co-operative system was originated by Dean Herman Schneider twenty years ago.

Under the co-operative plan the students spend alternate periods at the university and at work in industry. While one student is in school, his alternate is receiving practical training in some factory or office, and vice versa. In this way both the school and the shop are always fully manned. The theory learned in the classroom is thus applied in industry, and the problems which arise in industry are brought to the classroom.

Canada Northern Power Buys Ontario Company's Holdings

A deal has been completed by which the Canada Northern Power Corp., Ltd., takes over the greater part of the holdings of the Northern Ontario Light & Power Co. This transaction means that the Northern Canada Power Corp. now controls the principal power services of the Northern Ontario mining region. It also completes a series of changes during the last couple of years, which considerably alter the aspect of the power situation in the northern field.

Obituary

Ernest H. Elzemeyer, president and treasurer of the American Pulverizer Co., St. Louis, Mo., manufacturer of the American Ring Type Crushers, died suddenly April 16. Mr. Elzemeyer was in the sixty-second year of his age.

William H. Forde, electrical engineer with Stone & Webster, Inc., was killed in an automobile accident on May 11, near Conowingo, Md. Mr. Forde was riding with several companions when the machine struck a culvert and turned turtle.

A native of Natick, Mass., and a graduate of Sheffield Scientific School at Yale University in 1913, Mr. Forde entered the employ of Stone & Webster the following year. He was a member of the Yale Club of Boston, the American Institute of Electrical Engineers and the Yale Engineering Society.

Personal Mention

F. A. de Costa, recently designer with the Public Service Corporation of New Jersey, is now an engineering inspector for the Consolidated Gas Co. of New York.

I. E. Moultrop, superintendent of construction, with the Edison Electric Illuminating Company of Boston, has been promoted to chief engineer.

R. B. MacDonald, president of the Tri-City group of power utilities, Iowa, has been elected to the board of directors of the United Light & Power Co., Davenport, Iowa.

R. D. Martin, formerly with the New York Edison Co., Waterside Stations, is now associated with the Chuse Engine & Manufacturing Co., in its New York City office, at 50 East Forty-Second Street.

J. C. Woodson, former section engineer in charge of industrial heating, has been appointed manager of the Industrial Heating Engineering Department of the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Albert V. Brouillette, formerly industrial engineer of the Westinghouse Electric & Manufacturing Co., at East Springfield, Mass., has resigned to accept a similar position with the Savage Arms Corp., of Utica, N. Y.

Louis Hausmann, formerly of the general engineering department of the South Philadelphia Works of the Westinghouse Electric & Manufacturing Co., has been appointed a power engineer in the Chicago district offices.

E. E. Elzemeyer, son of the late Ernest H. Elzemeyer, president of the American Pulverizer Co., manufacturer of American Ring Type Crushers, was

elected president of the company at a meeting of the board of directors May 6. The policy of the company will continue as in the past.

Fred H. Daniels, general manager of the Riley Stoker Corp., has been elected president to fill the vacancy resulting from the death of R. Sanford Riley.

Society Affairs

The Franklin Institute, Philadelphia, announces the formal presentation of a portrait of Dr. Samuel Insull, president, the Commonwealth Edison Company of Chicago, and donor of the Franklin Medal, in the hall of the institute the afternoon of May 21 at 4 o'clock. B. E. Sunny will speak on "Samuel Insull, a Many-Sided Man." Louis A. Ferguson will make the presentation address and W. C. L. Eglin that of acceptance. Mr. Insull, in person, will make some remarks.

Business Notes

Oil Engine Power, a Freeman-Palmer publication, announces removal from 27 Pearl St., New York City, to 220 West 42d St.

The Gulf Oil Burner Company, a subsidiary of the Gulf Oil Corporation of Pittsburgh, Pa., has been incorporated to manufacture and sell a line of domestic oil burners.

Dwight P. Robinson & Co. is preparing plans and specifications for a new 18,000-hp. boiler plant at the Aliquippa Works of the Jones & Laughlin Steel Corp.

Dwight P. Robinson & Co., 125 East 46th St., New York City, have been awarded by the New York Steam Corp. the general contract for construction of a new steam plant from plans prepared by Thomas E. Murray, Inc. The ultimate boiler capacity will total 120,000 hp. The initial installation will be 30,000 horsepower.

Stone & Webster, Inc., has been authorized to double the tranmission facilities from the Dupont Circle Substation of the Edison Electric Illuminating Company of Brockton at Brockton, Mass., to the lines of the Montaup Electric Co., a distance of about 14 miles.

Black & Decker Manufacturing Co., Towson, Md., is calling in all outstanding first mortgage bonds remaining from the issue of Dec. 1, 1920, for payment June 1, according to announcement by S. D. Black, president of the company.

The Graybar Electric Co., of New York, reports several important street-lighting contracts received in Eastern and Southern cities. For the Allen J. Saville Real Estate Development Co., of Richmond, Va., 83 octagonal Chicago concrete standards; for Steelton, Pa., 112 King standards complete with Novalux fixtures, and to be installed at Sanford, Fla., 374 Kink standards complete with Form 13 Novalux units and King potheads, together with 72,000 ft. of park cable.

Coming Conventions

American Boiler Manufacturers Association. D. W. Glanzer, 840 Rockefeller Bldg., Cleveland, Ohio. Annual convention at Homestead, Hot Springs, Va., June 1-2.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Regional meeting at Niagara Falls, May 26-28. Annual convention at White Sulphur Springs, W. Va., June 21-25.

American Order of Steam Engineers. W. S. Wetzler, 758 N. 44th St., Philadelphia, Pa. Annual convention at Moose Hall, Philadelphia, June 7-11.

American Society for Testing Materials. C. L. Warwick, 1315 Spruce St., Philadelphia, Pa. Convention at Haddon Hall, Atlantic City, N. J., June 21-25.

The American Society of Heating and Ventilating Engineers, A. V. Hutchinson, 29 West 39th St., New York City. Annual convention at Lexington, Ky., May 26-28.

American Society of Mechanical Engineers. Calvin W. Rice, 29 West 39th St., New York City. Spring convention at San Francisco, Calif., June 28-30.

American Water Works Association. W. M. Niesley, Assistant to Sec., 170 Broadway, New York City. Annual convention at Hotel Statler, Buffalo, N. Y., June 7-12.

Association of Iron & Steel Electrical Engineers. John F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Exposition and convention at Hotel Sherman, Chicago, Ill., June 7-10.

Canadian Association of Stationary Engineers. G. A. Brown, secretary, Major St., Toronto, Ontario. Convention and exposition, London, Ontario, June 29.

Master Boiler Makers Association. Harry D. Vought, 26 Cortlandt St., New York City. Annual convention at the Statler Hotel, Buffalo, N. Y., May 25-26.

National Association of Stationary Engineers. F. W. Raven, 417 South Dearborn St., Chicago, Ill. Convention at Atlantic City, begins Sept. 14. Erroneously announced as Sept. 6-11. Annual conventions and exhibitions of state associations are scheduled for the following dates:

Illinois State Association. O. Jacobsen, 837, Lakeside, Place, Chicago. Convention at Decatur, Ill., June 2-4; **New England States Association,** Freeman L. Tyler, 32 Briggs St., Taunton, Mass. Convention at New Bedford, Mass., June 16-19; **Ohio State Association.** T. S. Garrett, 2622 E. Second St., Dayton, Ohio, Convention at Newark, Ohio, June 17-19; **Connecticut State Association,** George F. Klopfer, 30 East Pearl St., New Haven, Conn., Convention at Norwich, Conn., June 25-26; **Wisconsin State Association,** R. L. Scott, Eau Claire, Wis. Convention at Milwaukee, Aug. 3-6; **Minnesota State Association,** C. A. Nelson, 800 22nd Ave., N. E. Minneapolis, Minn. Convention at Rochester, Minn., Aug. 4-6; **New Jersey State Association,** S. G. Dalrymple, 111 Hutton St., Jersey City. Convention at Atlantic City, Sept. 12; **Pennsylvania State Association,** Frank J. McCarron, 3647 North 11th St., Philadelphia, Convention at Philadelphia, Sept. 12-13.

National Board of Boiler and Pressure Vessel Inspectors. Annual meeting at Chicago, May 24-26.

National District Heating Association. D. L. Gaskill, Greenville, Ohio. Convention at Niagara Hotel, Niagara Falls, June 1-4.

Universal Craftsmen Council of Engineers. 24th convention and exhibit Milwaukee Auditorium, Milwaukee, Aug. 3-7.

The Chuse Engine & Manufacturing Co., Mattoon, Ill., anounces that R. D. Martin, formerly with the New York Edison Co. at Waterside Stations, is now associated with the company at its New York City office, 50 East Forty-second Street.

Trade Catalogs

Blowers—Clarage Fan Co., Kalamazoo, Mich. An engineering reference book, No. 312, describing the new type of F.D. blower recently developed by the company.

Tachometers—The Bristol Co., Waterbury, Conn. A profusely illustrated catalog with several specimen charts and numerous diagrams and figures of the several kinds and styles of recording and indicating tachometers made by this company. Among the featured products are the combination of indicating and recording instruments. Catalog 1700.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run except Pittsburgh gas slack:

Bituminous Net Tons	Market Quoting	May 17 1926
Pool 1	New York	$2.50@$2.75
Smokeless	Boston	2.10
Clearfield	Boston	1.70@ 2.00
Somerset	Boston	1.85@ 2.10
Kanawha	Columbus	1.40@ 1.75
Hocking	Columbus	1.40@ 1.75
Pittsburgh	Pittsburgh	1.75@ 1.90
Pittsburgh gas slack	Pittsburgh	1.45@ 1.55
Franklin, Ill.	Chicago	2.35@ 2.50
Central, Ill.	Chicago	2.00@ 2.15
Ind. 4th Vein	Chicago	2.10@ 2.25
West Ky.	Louisville	1.10@ 1.40
S. E. Ky.	Louisville	1.35@ 1.65
Big Seam	Birmingham	1.75@ 2.25
Anthracite Gross Tons		
Buckwheat No. 1.	New York	1.70@ 3.50
Buckwheat No. 1.	Philadelphia	2.00@ 2.75
Birdseye	New York	1.30@ 2.00

FUEL OIL

New York—May 20, light oil, tank-car lots; 28@34 deg. Baumé, 5¾c. per gal.; 36@40 deg., 6½c. per gal. f.o.b. Bayonne, N. J.

St. Louis—May 11, tank-car lots, f.o.b. St. Louis; 24@26 deg., $2.10 per bbl.; 26@28 deg., $2.15 per bbl.; 28@30 deg., $2.20 per bbl.; 30@32 deg., $2.25 per bbl.; 32@36 deg., gas oil, 5.9c. per gal.; 38@40 deg., 6.5c. per gal.

Pittsburgh—May 11, f.o.b. local refinery; 30@34 deg., fuel oil, 6c. per gal.; 36@40 deg., fuel oil, 6¾c. per gal.

Dallas—May 15, f.o.b. local refinery 26@30 deg., $1.60 per bbl.

Philadelphia—May 13, 27@30 deg., $2.31@$2.37 per bbl.; 18@22 deg., $1.93@$1.99; 13@19 deg., $1.68@$1.74 per bbl.

Cincinnati — May 18, tank-car lots f.o.b. local refinery, 24@26 deg. Baumé, 6½c. per gal.; 26@30 deg., 6⅝c. per gal.; 30@32 deg., 7c. per gal.

Chicago—May 17, tank-car lots f.o.b. Oklahoma, freight to Chicago, 92c. per bbl.; 24@26 deg., $1.30@$1.35 per bbl.; 26@30 deg., $1.40; 30@32 deg., $1.60@ $1.65.

Boston—May 17, tank-car lots, f.o.b. 12@14 deg. Baumé, 4.42c. per gal.; 28@32 deg., 5¾c. per gal.

New Plant Construction

Ark., Hot Springs — Army & Navy General Hospital, Constructing Quartermaster, will receive bids until June 10, for the construction of a power plant, laundry, etc., for hospital.

Calif., Ramona—Ramona Irrigation Dist., voted $91,000 bonds for the construction of pipe line, pumping plants, reservoirs, pumps, etc. T. K. King, 920 8th St., San Diego, is engineer.

Calif., Tranquillity—Tranquillity Irrigation Dist., R. C. M'Farland, Secy., will receive until June 1, for one vertical deep well turbine pump equipped with a 10 hp. 3 ph., 220 v. 60 cycle, motor and switchboard.

Calif., Vernon (mail Watts) — Baldridge Packing Co., Inc., Los Angeles, had plans prepared for the construction of a 2 story packing plant including refrigeration and power plants, etc. Estimated cost $40,000. J. Allen, 1210 90th Place, Los Angeles, is architect and engineer.

Ill., Chicago—Delaware Place Building Corp., c/o E. L. Berman, 2310 Indiana Ave., will soon award contract for the construction of a 16 story apartment at Delaware Place and Rush St. Estimated cost $500,000. J. A. Armstrong, 127 North Dearborn St., is architect.

Ill., Chicago — Garfield Park Hospital, 3813 West Washington Blvd., is having plans prepared for the construction of an 8 story hospital at 3821-3825 West Washington Blvd. Estimated cost $650,000. Schmidt, Garden & Martin, 104 South Michigan Ave., are architects.

Ill., Dupo — City is having preliminary plans prepared for the construction of a waterworks and distribution system including pumping equipment, tank on tower, mains, etc. Estimated cost $125,000. Schwab & Sheppard, Alton, are engineers.

Ind., Kentland—Penick & Ford, plans the installation of centrifugal pumps, motors, cast iron pipe and fittings, pump connections, etc. in water settling basin. Estimated cost $25,000. F. Friedline, is engineer.

Me., Belfast—The Radio Corp. of America, 66 Broad St., New York, N. Y., awarded contract for the construction of a high power receiving station here, to Skinner & Cook, 280 Madison Ave., New York, N. Y. Estimated cost $50,000.

Mass., Cambridge (Boston P. O.) — Middlesex County Commissioners, A. Cutting, Chn. County Court House, plans the construction of a power house. Estimated cost $175,000. Engineer not selected.

Mass., Lakeville—Dept. of Public Health, G. M. Bigelow, Comr., State House, will receive bids until May 28, for the construction of a pumping station, 200 g.p.m. capacity, adjacent to shores of Clear Pond, also transmission lines for State Sanitorium. Estimated cost $25,000.

Mass., Milton (Boston P. O.)—Granite City Ice Co., 550 Adams St., East Milton, plans the construction of a refrigeration plant, here. Estimated cost $40,000. Architect not selected.

Mich., Detroit—Public Lighting Commission, 174 East Atwater St., will receive bids until June 7, for heating and ventilating system, switch house, heating return pump, electrical heating equipment, etc., for municipal power and light plant. Smith, Hinchman & Grylls, 800 Marquette Bldg., are engineers.

Mich., Detroit — Temple M. E. Church, West Grand Blvd., plans the construction of a 9 story office and apartment building including steam heating boiler and equipment. Estimated cost $850,000. J. I. Disc, 324 McKerchey Bldg., is architect.

Miss., Gulfport — Syndicate, c/o A. L. Jagoe, V. Pres. First National Bank, plans the construction of an 8 story hotel at Herald Square and 23rd Ave. Estimated cost $1,000,000. J. W. Billingsley, Interstate Bldg., New Orleans, La., is engineer.

Mo., St. Louis—City, J. Pritchard, Dir., City Hall, rejected bids for four forced draft chain grate stokers for waterworks at Howard's Bend on Missouri River. Estimated cost $40,000.

Mo., St. Louis — Wagner-Grant-Bell Realty Co., International Life Bldg., plans the construction of a 14 story apartment at Skinker and Rosebury Sts. Estimated cost $1,000,000. Work will be done by subcontracts under the supervision of P. J. Bradshaw, International Life Bldg., Archt.

N. J., Rahway — Bd. of Water Commissioners, R. K. Miller, Pres., will receive bids until June 7 for the construction of a new filter plant, coagulation basin, new electric pumps, etc. Estimated cost $163,000. Hazen & Whipple, 25 West 43rd St., New York, N. Y., are engineers.

N. Y., Buffalo — General Electric Co., H. S. Jacoby, V. Pres., Electric Bldg., awarded contract for the design and construction of addition to plant to H. K. Ferguson Co., Military Road, Kenmore. Estimated cost $100,000.

N. Y., New York — New York Steam Corp., 280 Madison Ave., awarded contract for the construction of a new steam plant, initial capacity 30,000 hp., ultimate total capacity 120,000 hp. on East 35th St., to Dwight P. Robinson & Co., Inc., 125 East 46th St. Estimated cost $400,000.

N. Y., New York — J. G. Siegel, c/o Sugarman & Berger, 345 Madison Ave., Archts., is having plans prepared for the construction of a 27 story hotel. Estimated cost $1,145,000.

N. Y., Yonkers—Bardley Realty Co., c/o Deutsch & Schneider, 35 Maiden Lane, New York, Archts., is having plans prepared for the construction of a hotel on Park Hill, here. Estimated cost $1,300,000.

N. C., Raleigh—State Hotel Co., awarded contract for the construction of an 8 story hotel on Dawson St. to C. V. York, Citizens Bank Bldg. Estimated cost $500,000.

N. D., Crosby — City will receive bids until June 7, for the construction of a waterworks system including well, pump house, 100,000 gal. storage reservoir, 50,000 gal. tank, etc. Estimated cost $35,000. Dakota Engineering & Construction Co., Valley City, is engineer.

Okla., Hydro—City is having preliminary plans prepared for improvements to waterworks including new well, pump and motor, etc. Estimated cost $17,000. Engineer not selected.

Okla., Oklahoma City—W. R. Ramsey, Security Bldg., is having preliminary plans prepared for the construction of an 18 story office building on Robinson St. Estimated cost $700,000. Architect not selected, lected.

Okla., Potean — City had preliminary plans prepared for the construction of a new 400 hp. Diesel engine, electric light plant. Estimated cost $60,000. J. E. Davis, is engineer.

Pa., Aliquippa—Jones & Laughlin Steel Corp., Ross St., Pittsburgh, plans the construction of a new 18,000 hp. boiler plant here. Dwight P. Robinson & Co., Inc., 125 East 46th St., New York, N. Y., are engineers.

Pa., Avis—New York Central R.R., 466 Lexington Ave., New York, N. Y., awarded contract for reconstruction and alterations to boiler house here, to W. M. Bullard, Inc., Syracuse, N. Y. $50,000. G. W. Kittredge, is chief engineer.

Pa., Fox Chase (Philadelphia P. O.)—John J. Nesbitt, Inc., c/o Ballinger Co., 12th and Chestnut Sts., Philadelphia, Archts., will soon award contract for the construction of a manufacturing plant and boiler room at Rahn St. and State Road, here.

Pa., Philadelphia—D. Barton, 1218 Chestnut St., awarded contract for the construction of a 12 story office building at Juniper and Arch Sts., to P. M. Sax, Penfield Bldg. Estimated cost $500,000.

Tenn., Franklin—Lillie Mill Co., plans the construction of a mill. Horner & Wyatt, 300 Board of Trade Bldg., Kansas City, Mo., are architects. Motors, separators, 2,000 bu. scale elevator and conveyors will be required.

Tex., Abilene—Abilene Hotel Co., has acquired a site and plans the construction of a 10 story hotel. Estimated cost $500,000.

Tex., Corpus Christi — S. Robertson, Brownsville, is having plans prepared for the construction of a waterworks system, light plant, etc., here. Estimated cost $100,000. George F. Green Co., Inc., Tampa, Fla., is engineer.

Tex., Dallas—Lake Cliff Apartment Corp., W. S. Bellous, Pres., Oklahoma City, Okla., awarded contract for the construction of a 10 story hotel including steam heating plant at Zangs Blvd. and Colorado St., to Bellaus & Maclay, 611 Kirby Blvd. Estimated cost $750,000.

Tex., Galveston — High Grade Packing Co., 2627 Ave. D., plans the construction of a packing plant. Estimated cost $50,000. Stowe & Stowe, 311½ 22nd St., are engineers. New refrigeration machinery will be required.

Tex., Houston — Houston Lighting & Power Co., S. R. Bratton, Electric Bldg., awarded contract for the construction of an additional 25,000 kva. electric generator unit to Texas Construction Co., Electric Bldg., $2,000,000.

Tex., San Antonio — E. Goeth & Associates, Corpus Christi Road, plans irrigation of 277 acres in Bexar County. Estimated cost $75,000. Engines, pumping equipment, etc., will be required.

Tex., Sequin—Sequin Electric Power Co., c/o A. P. Stautzenberger, mayor, plans improvements to municipal power plant including 400 hp. oil engine, new turbine, etc. Estimated cost $20,000. Engineer not selected.

Tex., Sinton — Texas Central Power Co., Frost Bldg., San Antonio, will build a 70 ton ice plant by day labor here. Estimated cost $100,000. Private plans, R. D. Barron, c/o owner, is superintendent of construction.

Tex., Wichita Falls—City plans and election June 5, to vote $1,200,000 bonds for improvements to waterworks including pumping plant, filter and softening plants, etc. at Lake Wichita. T. U. Taylor, University Station, Austin, is consulting engineer. W. E. McBroom, is secretary.

Wash., Aberdeen—City plans an election June 29, to vote $2,000,000 bonds for the construction of Wynooche hydro-electric development. W. J. Roberts, Tacoma, is consulting engineer.

Wis., Madison—University of Wisconsin, J. S. Phillips, Bus. Mgr., is receiving bids for ice and refrigeration machinery, cold storage insulation, etc., for refectory building. A. Peabody, State Capitol, is engineer.

Wis., Shawano — Wisconsin Power & Light Co., 16 North Carroll St., Madison, is having plans prepared for concrete dam on Wolf river near here. Estimated cost $25,000. Power Engineering Co., 621 Metropolitan Life Bldg., Minneapolis, Minn., is engineer.

Ont., Lakefield — Canada Cement Co., Canada Cement Bldg., Montreal, Que., plans the construction of a 2,300 hp., 16 ft. head hydroelectric generating station including dam, power house, etc., here. Estimated cost $250,000. Kerry & Chace, Ltd., Confederation Life Bldg., Toronto, Ont., are engineers. Contract for turbine and generator awarded.

Ont., Oshawa—W. C. Smith, Engr., will receive bids until May 27 for a 1,000 g.p.m. pump direct connected to 3 ph. 60 cycle 550 v. motor against a 240 ft. head for Bd. of Water Commissioners.

Ont., Toronto — Toronto East General Hospital, 133 Danforth Ave., plans the construction of a 5 story hospital including separate power and heating plant, steam boilers, etc. at Coxwell St. and Sammon Ave. Estimated cost $500,000. Architect and engineer not selected.

Ont., St. Catharine — Silverwoods Ltd., London, plans the construction of a dairy and refrigeration plant. Estimated cost $75,000. Private plans.

N. Z., Wellington—New Zealand Government Railways, will receive bids until August 30, for two 750 r.p.m., 40 b.h.p protected slipping motors and one 750 r.p.m. 40 b.h.p. fully enclosed, pipe ventilated, self ventilating motor.